

EDITION B

The Journal of the
**INSTITUTION OF
PRODUCTION
ENGINEERS**

Vol. XXI



No. 9

SEPTEMBER, 1942

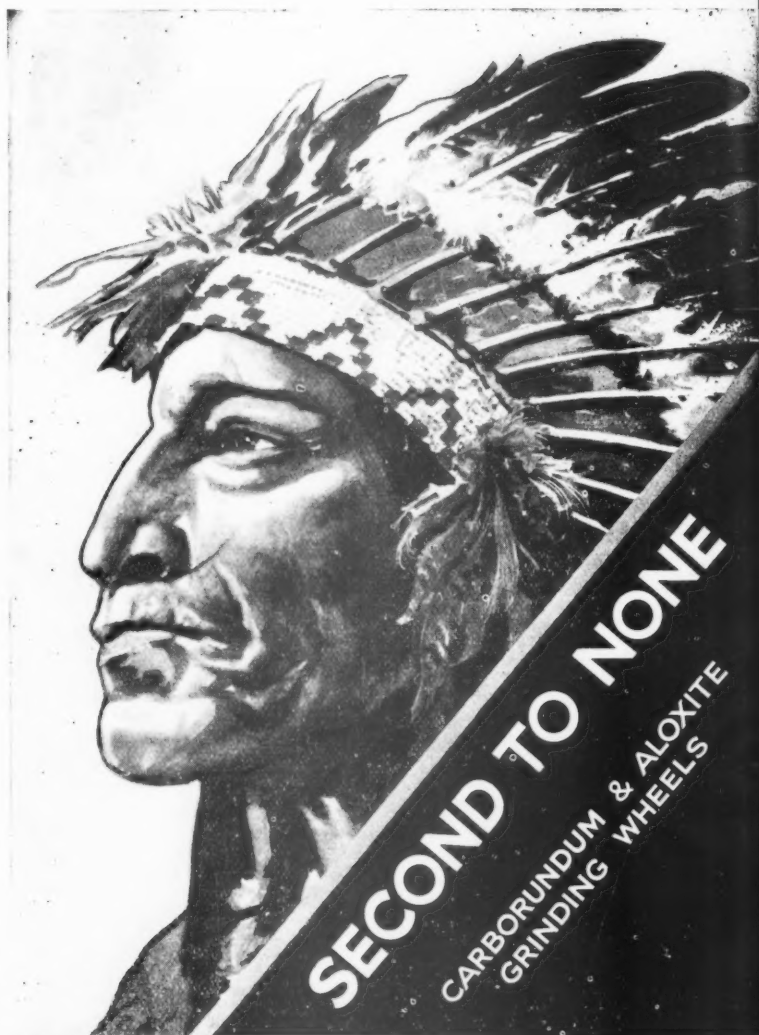
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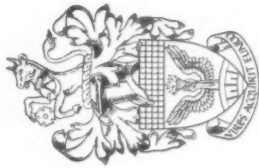
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THE INSTITUTION OF PRODUCTION ENGINEERS

President : G. E. Bailey, M.I.P.E., M.I.Mech.E.

General Secretary : Richard Hazleton

Telephone : Welbeck 2233



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Dear Fellow Member,

YOUR PART IN HELPING THE WAR-WORK
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What is *your* solution to the problem of increasing production?

Not long after the formation of the Technical and Publications Committee I wrote to a large number of members asking for a contribution to *The Technical Bulletin* or *The Journal* on one or other of the wide range of production engineering problems with which members of the Institution have had to deal since the beginning

Not long after the formation of the Technical and Publications Committee I wrote to a large number of members asking for a contribution to *The Technical Bulletin* or *The Journal* on one or other of the wide range of production engineering problems with which members of the Institution have had to deal since the beginning of the War.

The response was very encouraging, and many worth-while contributions were received, a large number of which have, from time to time in recent months, been published either as complete articles or in the form of suitable extracts.

I am now making a further appeal on a wider basis, and I am confident that this appeal will be even more successful than the last. We have heard from many sources since *The Technical Bulletin* has been published that the information contributed and made available to our members has proved to be very valuable. The Committee is convinced that there is a wealth of information on out-of-the-ordinary production technical matters locked up in the experience of individual members or companies which, if made available to the thousands of other members, would prove of great value to them in their own particular work.

Many members have put forward the claim that the requirements of the Official Secrets Act preclude the publication of much interesting information. This is true, but we are quite convinced that even after due regard has been paid to this important matter, there are many problems which could be given wider publicity than they have at present received.

I am therefore making a personal appeal to you to look into your own experiences and to consider seriously whether you have contributed as much to the knowledge of your fellow-members as you have received from others.

If you feel the balance is on the debit side may I ask you to let us know whether you would be prepared to assist us in increasing the amount and value of the technical information we are anxious to spread among not only our members but many other bodies and departments in which our technical literature is circulated.

As a Production Engineer you will know that our job covers a very wide sphere, but in order to give you some indication of the subjects on which we are particularly anxious to obtain information, I am giving on the enclosed Business Reply Card a list of suitable headings. I would also be glad to know whether you would be prepared to open or take part in Informal Discussions at meetings of your Local Section on any of the subjects listed, or other subjects directly bearing on our War effort which you might suggest. It is not necessary of course that you should restrict yourself to the headings on the Card, but from enquiries received from many of our members these specific subjects seem to be predominant among the many worries confronting our profession to-day.

You may rest assured that the Committee knows the strain under which you are at present working, and the difficulty of fitting in that one extra job. On the other hand we know also that the busy man can usually be relied upon to produce something, and after all if the Institution is to maintain the important place it has gained

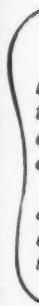
You may rest assured that the Committee knows the strain under which you are at present working, and the difficulty of fitting in that one extra job. On the other hand we know also that the busy man can usually be relied upon to produce something, and after all if the Institution is to maintain the important place it has gained over the past few years you, as a Member, will I am sure agree that you must do your share in keeping on the credit side.

Can I rely upon you to fill in the Business Reply Card and send to Headquarters at the earliest possible moment?

Yours sincerely,

A handwritten signature in dark ink, appearing to read "D. H. Buckley". The signature is written in a cursive style with a large, looped initial "D".

Chairman, Technical & Publications Committee.



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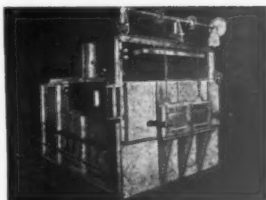
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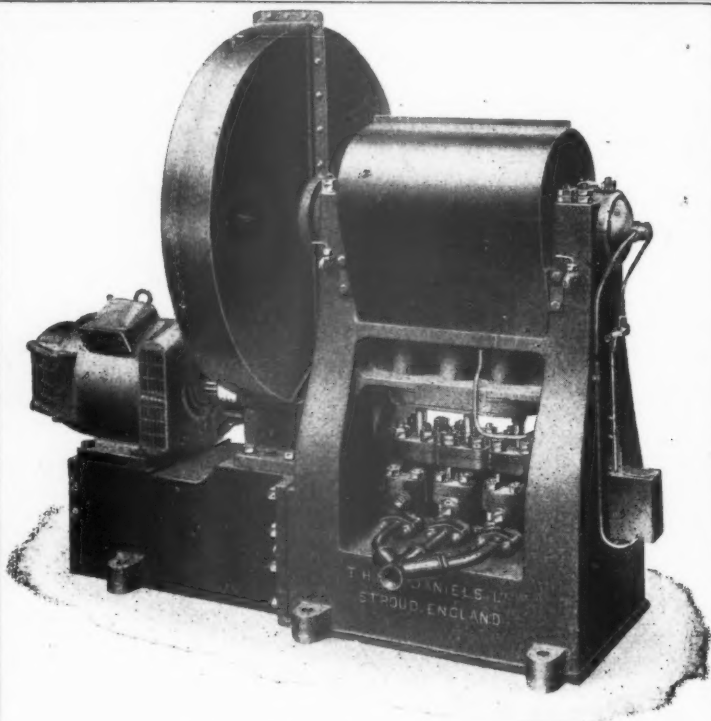
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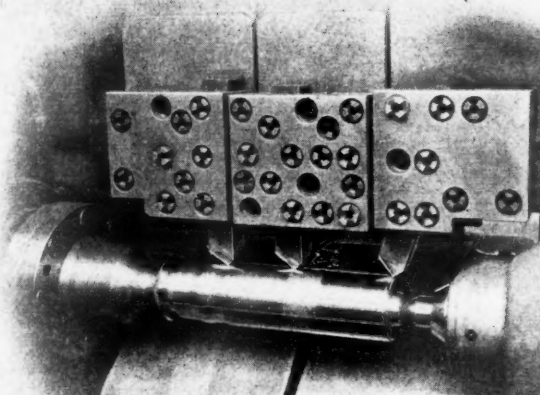
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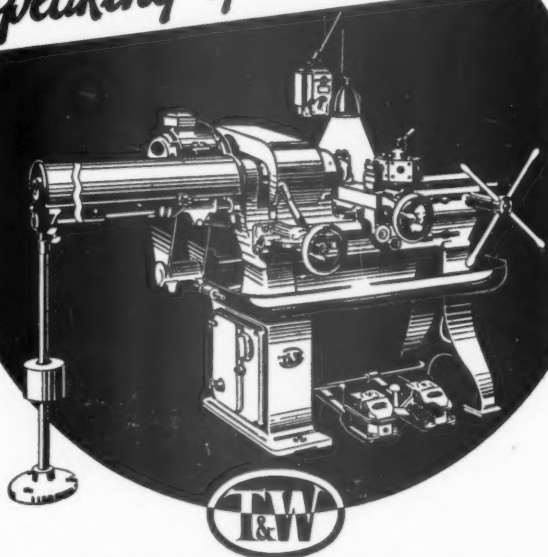
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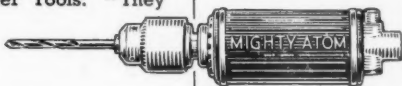
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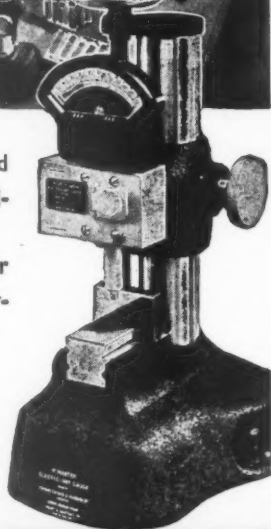
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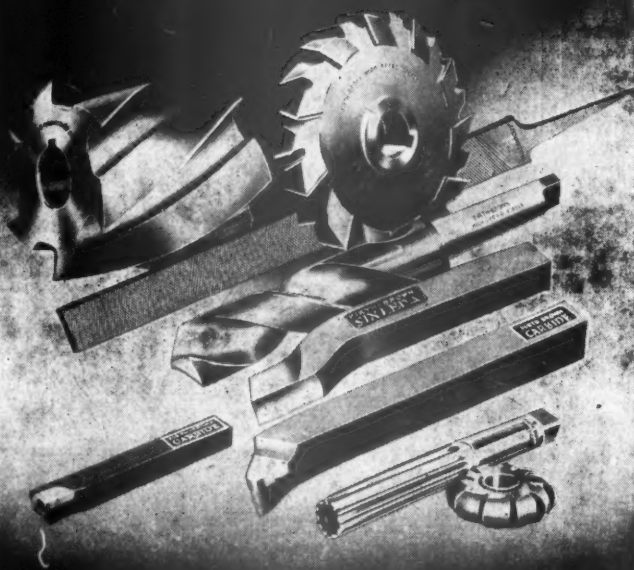


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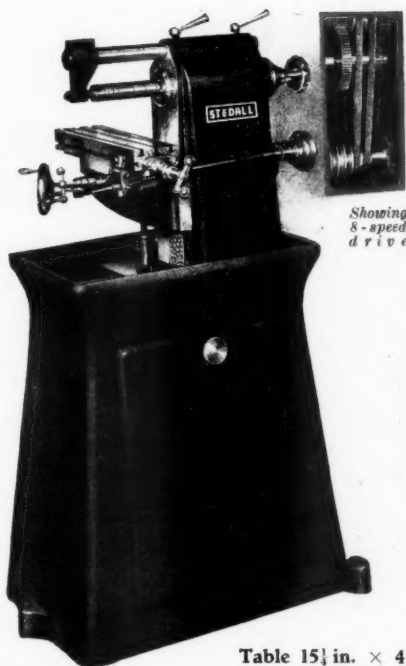


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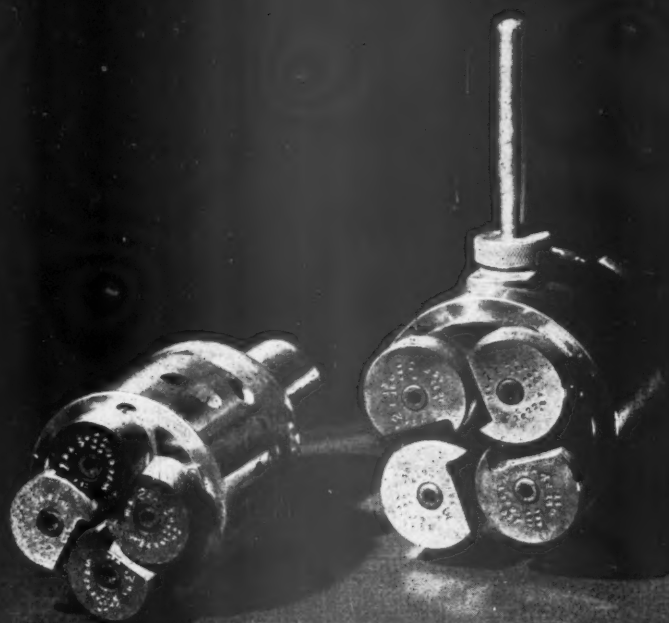
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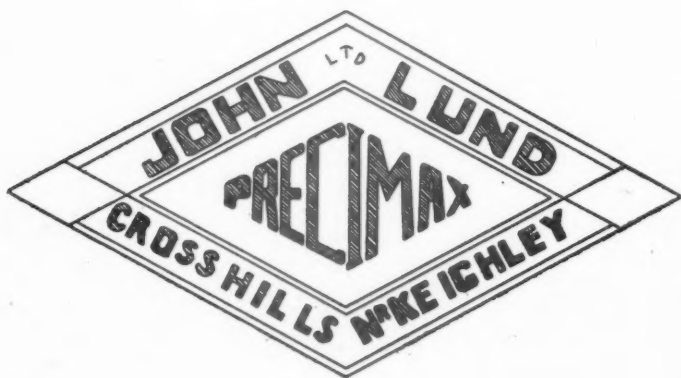
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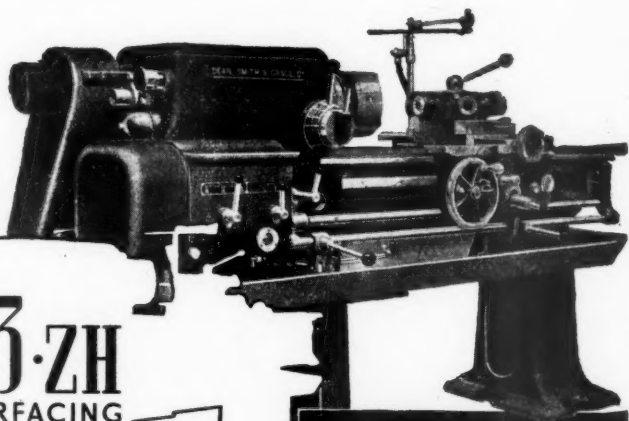
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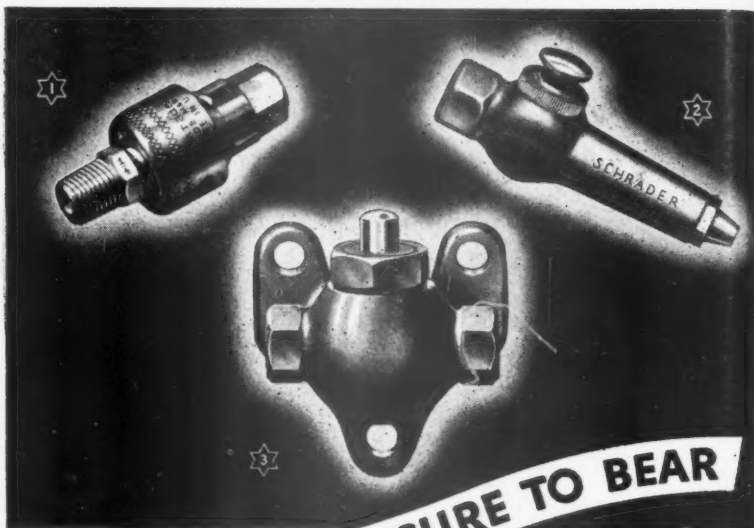


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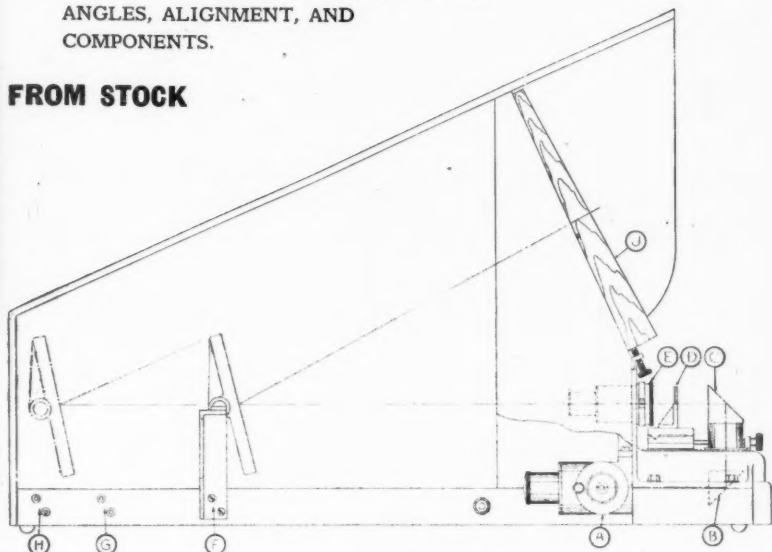
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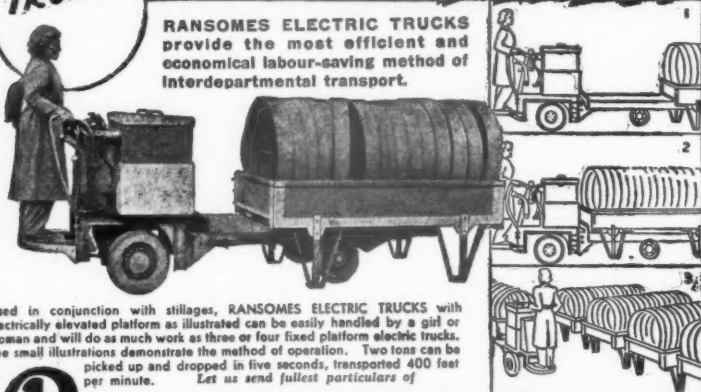
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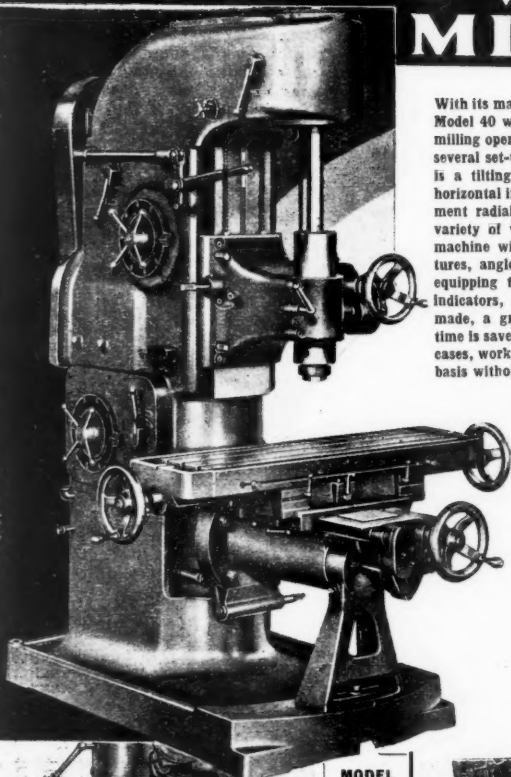
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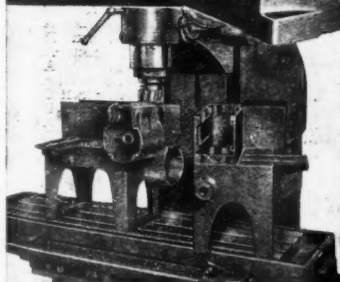
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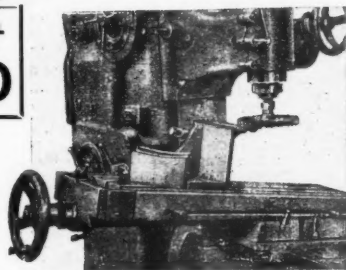
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MANCHESTER: CENTURY HOUSE, ST. PETER'S SQ. Phone: Central 6239

GLASGOW: BATH CHAMBERS, 20, WELLINGTON ST. E. 2. Phone: Central 1067

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As a war-time measure the advertisement section of this Journal is now published in two editions, A and B. Advertisers' announcements only appear in one edition each month, advertisements in edition A alternating with those in edition B the following month. This Index gives the page number and edition in which the advertisements appear for the current month.

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The fact that goods made of raw materials in short supply owing to war conditions are advertised in "The Journal" should not be taken as an indication that they are necessarily available for export.



Changes of Design

are occurring continuously in war-time with every type of weapon. Lessons must be learned quickly from battle experience and rapid adaptation to new developments is a vital necessity. If production is to keep pace with these ever changing demands a completely flexible system of works routine is essential.

'B & A' SIMPLEX

MECHANISED PRODUCTION ROUTINE

provides complete control combined with complete flexibility.



Write to the Systems Department

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'OLD MILL HOUSE' • TRUMPINGTON ROAD • CAMBRIDGE
Telephone: Trumpington 305 (3 lines)

Branches at Belfast, Birmingham, Bristol, Cardiff, Glasgow, Liverpool, London, Manchester, Newcastle, Nottingham, Sheffield, Southampton

Bratby



The "Bratby" deals with every variety and size of component and whether the metal be steel or aluminium, cast iron, or bronze there is a machine and process for it. British manufacturers who are wanting a cleaner should instal a Bratby Cleaner designed to suit their special needs. Send now for full particulars of the machine suitable for your particular job, or better still, ask our representative to call for a discussion.

THERE IS A BRATBY CLEANER TO SUIT EVERY TYPE OF JOB

Sole Agents for Gt. Britain :

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Designed and manufactured by :

BRATBY & HINCHLIFFE LTD., SANDFORD STREET, ANGOATS, MANCHESTER, 4

INSTITUTION NOTES

September, 1942

Twenty-First Birthday Celebration Meeting, October 23

The Right Hon. Oliver Lyttelton, M.C., M.P., Minister of Production, will be the guest of honour at the Twenty-First Birthday Celebration Meeting of the Institute to be held on Friday, October 23, 1942, at the Institution of Civil Engineers, Great George Street, Westminster, S.W.1., at 3 p.m. This Celebration Meeting is being combined with the Annual General Meeting (see official notice below). Mr. G. E. Bailey, outgoing President, will first preside and will later hand over the chair to the incoming President, Sir Ernest Lemon. Tea will be served following the meeting, at 4-30 p.m.

Members will be entitled to bring one guest. **Those intending to be present are particularly requested to apply for a ticket on the postcard supplied for this purpose and to state thereon the name of their guest, if any.**

Annual General Meeting : Official Notice

NOTICE IS HEREBY GIVEN that the Annual General Meeting of the Institution will be held on Friday, October 23, 1942, at the Institution of Civil Engineers, Great George Street, Westminster, London, S.W.1., at 3 p.m.

AGENDA :

1. Notice convening Meeting.
2. Minutes of previous Annual General Meeting.
3. Annual Report of the Council, Annual Report of the Research Executive and Annual Accounts for the year ended June 30, 1942.
4. Election of Auditors for 1942-43.
5. Report on Election of President and Members of Council.
6. Votes of thanks.

By Order of the Council,

RICHARD HAZLETON,
General Secretary and Treasurer.

36, Portman Square,
London, W.1.

September 12, 1942.

Annual Elections to Council

I HEREBY DECLARE THAT the following candidates have been elected to fill the vacancies for seven Ordinary Members of Council for the year 1942-43, no ballot of members having been required : R. Broomhead, W. F. Dormer, H. A. Drane, J. France, E. J. H. Jones, F. C. White, F. Williams.

R. HAZLETON,

August 18, 1942.

General Secretary.

Newly Elected Members

As Members : F. Allen, S. F. Booth, J. T. Burford, A. B. Berry, E. Cuthbert, L. W. Farrer, A. G. Gardner, F. Hawtin, B. Holloway, B. Laycock, R. H. Line, W. G. Maw, T. McGlashan, H. Milnes, J. P. Smith, A. F. Shillington, A. G. Thursby, J. R. Thorpe, E. Watts.

As Associate Members : F. R. Avey, H. P. Browett, R. D. Bibby, E. Bernfeld, J. W. E. Brind, J. G. Bulger, J. V. Brown, W. Craig, W. B. Clarke, A. J. Caunt, W. Dickie, B. L. A. Dorizon, J. A. Dunlop, R. A. Duff, C. H. Edwards, C. L. Field, H. J. Fisher, F. H. Fox, W. E. Garlick, J. H. Gillett, G. A. Grantham, J. G. Holmes, S. D. Horbury, J. Hay, P. G. H. Jeffrey, G. J. Jennings, H. Kirkman, F. Lord, J. Lomas, T. G. H. Middleton, T. L. McDonald, E. Nobbs, A. C. Pellatt, H. Swaine, J. J. Venables, C. H. Walker, J. A. Wood, W. J. Webb, H. E. Ware, H. Yelland.

As Associates : C. R. A. Beesley, C. L. Caiger, G. E. Curry, T. Curzon, E. A. Diffield, T. W. Fazakerley, W. Hordley, R. S. Hart, J. L. Hardy, J. Kilshaw, C. H. Oaks, T. I. D. Pabst, H. G. Sissons, G. O. Taylor.

As Intermediate Associate Members : W. E. Brackenbury, L. Bullock, W. H. Bryce, H. C. Blackford, N. Butterfield, W. G. Baller, S. G. Barbet, W. F. Bryant, G. Bell, W. Cookson, W. G. Cutter, G. E. J. Finch, F. A. Goodyear, H. Hubbard, G. W. Huff, P. E. Irving, L. E. Jones, D. B. King, C. M. Kaye, A. Lyall, W. H. Littlejohn, H. Lloyd, W. J. Latty, E. N. Laxon, E. G. Milner, W. T. Orton, M. Perry, W. M. Reichsfeld, H. Rothwell, H. W. Rainbird, W. Sidebottam, A. E. Stenning, H. W. Tuxgord, S. H. Tratt, T. H. Ward, V. J. Wood, G. A. Wilson, A. Whitehead, L. L. M. Wilson.

As Graduates : W. Bailes, R. R. Brittain, L. Blackburn, H. R. Carr, E. Cooper, B. B. Dearden, W. I. Day, J. R. England, L. E. W. Good, K. A. Hurst, F. Hine, L. Hutchinson, S. G. Hayden, B. G. L. Jackman, J. H. Jarvis, K. G. Keeling, P. E. Mitchell, A. Marks,

INSTITUTION NOTES

P. H. Myerscough, S. Pearce, A. H. Poole, W. C. Rickards, W. H. Smith, C. J. Toyer, W. T. Vaughan, A. H. Willis, E. G. Worrall.

As Students : D. H. Appleton, C. P. Dixon, A. Felton, F. R. Fielding, J. R. Hindley, N. Herbert, D. C. Harrison, R. T. Houston C. R. Hill, R. D. Knight, D. R. G. Nash, J. D. Roberts, H. U. Rom, A. Shaw, R. E. Sawyer, P. G. J. Sargent, E. W. H. Scaifo, B. J. Stedhan, R. Turley, H. Townend, G. C. Walford.

As Affiliated Firms : Davey, Paxman & Co., Ltd. (Aff. Representative, E. P. Paxman and H. M. Thomson) ; Howard Wall, Ltd. (Aff. Representative, M. E. Esner) ; Manlove, Alliot & Co., Ltd. (Aff. Representative, H. E. King) ; Northern Aluminium Co. (Aff. Representative, S. E. Colworthy and G. H. Field) ; Bren Manufacturing Co., Ltd. (Aff. Representative, W. Winters) ; University of London Courtauld Institute (Aff. Representative, J. G. Lowe).

Transfers

From Associate Member to Full Member : W. J. Anstey, H. Burke, E. Carpenter, N. J. Cottell, R. E. Dunnett, H. Porter, J. R. Ward.

From Intermediate Associate Member to Associate Member : J. E. Fogg, A. E. Grocock, T. H. Steel.

From Graduate to Associate Member : D. M. Robinson.

From Graduate to Intermediate Associate Member : A. H. F. Bowness, R. E. Copelin, J. H. Cribb, R. D. Kerr, P. E. Moorhouse, F. Marsden, W. V. Mercer, F. E. Page, W. H. Rummey, D. G. Watkinson.

From Student to Graduate : J. G. Lowe, W. H. C. Webster.

Personal Notes

Mr. E. W. Hancock, M.B.E. (*Member of Council*), has been appointed Works General Manager of Rubery Owen & Co., Ltd., in charge of their Darlaston and other works. He was the recipient of handsome presentations from the directors and staff of Humber-Hillman, Ltd. on leaving after six years as Works Manager there.

Mr. J. E. Baty (*Member*), has joined the Council of the Institution as an additional representative from the London Section.

THE INSTITUTION OF PRODUCTION ENGINEERS

Mr. A. J. Bailey (*Member*), has been appointed Chairman of the Provisional Committee of the proposed South Wales and Monmouthshire Section, the Inaugural Meeting of which has been fixed for Tuesday, October 27, at Cardiff.

The Central Register

Members who come within the statutory definition of a production engineer are reminded that there is a legal obligation on them to enrol on the Central Register. The definition set out in the Statutory Order is as follows :

" A production engineer, that is to say a staff engineer who normally holds in an engineering works a position of authority involving responsibility for executive management or control above the rank of foreman, of any technical function pertaining to production."

Members are advised to notify Headquarters when they add their names to the Register. Changes of address should be notified direct to the Central Register, Sardinia Street, Kingsway, London, W.C.2.

Meeting of the Council

The Council met at Luton on September 18, Mr. N. V. Kipping, Chairman of Council, presiding, the other members present being, Messrs. J. E. Baty, J. E. Blackshaw, R. Broomhead, D. Burgess, W. F. Dormer, H. A. Drane, J. France, G. H. Hales, F. W. Halliwell, H. A. Hartley, J. T. Kenworthy, R. Kirchner, Major C. W. Mustill, A. E. Newby, W. Puckey, Dr. H. Schofield, F. Williams.

The President of the Luton Section, Mr. Pearson, (*Councilor-elect*), Mr. R. M. Buckle (*Hon. Secretary, Luton*), Mr. F. C. White (*Councillor-elect*), and Mr. J. Walters (*Luton Committee*) were also present.

ANNUAL REPORT OF THE COUNCIL FOR THE YEAR ENDED 30th JUNE, 1942

The Institution's Twenty-first Birthday

THE foundation meeting of the Institution was held at the Cannon Street Hotel, London, on February 26, 1921, so that on February 26, 1942, the Institution attained its twenty-first birthday. Present conditions make it undesirable to celebrate the event by a big luncheon such as that of September, 1941, when 800 members and visitors gathered at Grosvenor House, but it is proposed to hold a Twenty-First Birthday Celebration Meeting in conjunction with the Annual Meeting on Friday, October 23, 1942, at the Institution of Civil Engineers. At this meeting, Mr. G. E. Bailey will hand over the Presidency to Sir Ernest Lemon. The guest of honour at the Celebration Meeting will be the Rt. Hon. Oliver Lyttelton, P.C., M.P., Minister of Production.

Growth of the Institution

Until 1929, the Institution operated without an office or paid officials. Mr. A. T. Davey (*Member*) was the first Hon. General Secretary. He was succeeded by Mr. E. D. Ball (*Member*). In May, 1929, when membership was a little over 230 our present General Secretary, Mr. R. Hazleton, was appointed and an office was opened at 48, Rupert Street, off Piccadilly Circus. A year later a move was made to larger offices at 40, Great James Street, Holborn. In 1935 a further move was made to British Industries House, Oxford Street, and in 1938 our present premises at 36, Portman Square were taken over, Lord Nuffield, then President, having presented the lease of the building.

The following figures refer to the position at June 30 in each of the years shown :

Year	Membership	Subscription Income	Research Income	Total Income
		£	£	£
1929	244	572	—	699
1930	446	1,062	—	1,323
1931	662	1,191	—	1,511
1932	762	1,373	—	1,885
1933	866	1,603	—	2,242
1934	1,022	1,890	—	2,634

THE INSTITUTION OF PRODUCTION ENGINEERS

Year	Membership	Subscription Income £	Research Income £	Total Income £
1935	1,165	2,069	—	2,779
1936	1,360	2,499	—	3,292
1937	1,477	2,830	—	3,754
1938	1,687	3,149	—	4,155
1939	2,008	3,889	1,279	6,357
1940	2,316	4,396	2,961	8,485
1941	2,587	4,847	2,805	9,810
1942	3,030	5,929	6,005	15,332

Present Membership

The membership at the end of June, 1942, was as follows :

Honorary Members	...	...	...	...	3
Ordinary Members	...	...	...	...	843
Associate Members	...	...	...	...	1,052
Associates	...	...	...	...	67
Intermediate Associate Members	...	...	...	...	348
Graduates	...	...	...	...	468
Students	...	...	...	...	136
Affiliates, representing 134 Affiliated Firms, less those already in other grades	...	...	...	...	113
					<hr/> 3,030 <hr/>

Four hundred and ninety-seven new members were added to the register during the year, ten died, nineteen resigned and twenty-five lapsed. The members whose decease has to be recorded with regret were Mr. L. H. Pomeroy (*Member*), former President of the Institution of Automobile Engineers ; Mr. G. Hepworth (*Member*), a prominent member of the Yorkshire Section Committee ; Messrs. F. W. Anderton (*Associate Member*), E. Arnold, (*Member*), W. G. Berry (*Member*), J. Bishop (*Associate Member*), P. W. Boothroyd (*Member*), A. J. Brain (*Member*), H. W. Collier (*Graduate*) and E. G. A. Smith (*Graduate*). Since the end of June we also record with regret the decease of Messrs. H. F. Dalby (*Associate Member*), B. J. Hugo (*Member*), G. W. Marner (*Member*), H. G. Povey (*Member*), and R. F. Rogers (*Graduate*).

Finance

The accounts for the year ended June 30, 1942, again show a satisfactory record. The growth of the income of the Research Department is noteworthy. In view of the comprehensive Research Plan presented by the Executive Committee, there is every reason to expect that this expansion will continue.

Honours conferred on Members by the King

During the year Sir Charles Craven (*Hon. Member*) was created a baronet, Mr. H. H. Harley (*Member*) received the honour of C.B.E., and His Majesty approved the grant by the King of Greece to Major Percy R. Clark (*Member*) of the Greek Distinguished Service Order.

Appointments by the Minister of Production

Soon after taking up office as Minister of Production, Mr. Oliver Lyttelton appointed Mr. N. V. Kipping, Chairman of Council, as Head of the Regional Organisation Division of the Ministry. Serving on Mr. Lyttelton's Advisory Panel are Mr. G. E. Bailey (our retiring President), Sir Ernest Lemon (our incoming President), Mr. W. Puckey (Member of Council), and Mr. T. G. Spencer (*Member*). We are confident that these appointments will be a source of strength to the Ministry and wish our colleagues every success in the important work they have undertaken.

The Institution's War Work

It is a source of satisfaction to us, as we know it will be to our members in general, that during the past year the activities of the Institution in support of the national war effort have grown both in extent and importance. A large part of these activities have been carried out through our Headquarters' organisation and Committees operating from there. Some of these Committees have continued to meet every week and have done a great deal of most useful work. Only brief reference can be made in this report of some of these activities.

War Emergency Committee

The War Emergency Committee devoted its main attention to the problem of how production could best be increased without increasing the available facilities in the shape of machinery and labour. It prepared a memorandum on the subject which went forward in March in the name of the Council to the Minister of Production. The memorandum attracted wide notice on its publication, and in our opinion was one of the most useful of all the documents drawn up by the War Emergency Committee.

Technical and Publications Committee

This Committee, which still meets every week, has been fully occupied in preparing and supervising Institution publications such as *The Technical Bulletin* and *The Journal*; in co-operation with the Sub-Committees it has set up on Welding and Production Control; and in handling the very large number of technical enquiries which

THE INSTITUTION OF PRODUCTION ENGINEERS

reach Headquarters from members and others. Government officials from most of the Ministries have frequently attended meetings of the Committee for consultation on current problems relating to production. We place on record once more our appreciation of the time and effort put into the work by the members of this and other Committees.

Production Control Sub-Committee

The Articles of Association dealing with the Associate grade of membership have been amended so as to make better provision for admission to the Institution of executives in engineering works concerned with production control. Following this change, a Production Control Sub-Committee was set up under the chairmanship of Mr. W. C. Price by the Technical and Publications Committee. The first task was to draw up a satisfactory definition of Production Control and its constituent functions and to make recommendations as to main guiding principles.

A large part of this ground work had been completed by the Sub-Committee just as the British Standards Institution, at the instance of the Treasury and the Ministry of Production, got together an active group of specialists to prepare a series of booklets setting out recommended practice on Factory Office Systems. We have co-operated in this work. Members of our Production Control Sub-Committee compose most of the membership of the B.S.I. Sub-Committee on the subject and the results of their work for the Institution have been placed at the disposal of the B.S.I. There is no doubt that the absence of adequate schemes of production control, especially among the newer and smaller engineering companies, have been a serious weakness which should be rectified.

Welding Sub-Committee

Set up by the Technical and Publications Committee during the year, this Sub-Committee includes amongst its membership representatives of the Institute of Welding, the Welding Advisory Service of the Ministry of Supply and experts on welding from the production point of view. The Sub-Committee is occupied with inspection problems. Its first report is to be published shortly.

Local Section Activities

Schemes have been agreed on for securing the co-operation of our Local Section Committees and members throughout the country with the Regional officers of the Ministry of Production and certain of the Supply Departments. Between five and six hundred senior members have agreed to give voluntary part-time assistance if required on matters coming within their specialised experience. While we feel that not nearly enough use had yet been made of

the possibilities opened up by the agreements arrived at, co-operation is growing. The difficulties to be overcome in putting schemes into effective operation are not inconsiderable. It is mainly a question of getting suitable specific cases where advice can be helpful. Before the advice can be availed of it has to be sought. The good-will is there. Members of the Institution are making increasing use of this form of co-operation amongst themselves, and this is to be encouraged.

Most Local Sections have continued to hold meetings for lectures or informal discussions, though only in a few cases have the full normal numbers of such meetings been found convenient.

Education.

Progress has been made with the scheme for Higher National Certificates in Production Engineering. Several courses leading up to this certificate were approved during the year. Many Ordinary National Certificate Courses in Mechanical Engineering containing production subjects have also been approved for counter-signature by our President on behalf of our Institution.

Loughborough College has been the pioneer in promoting an Intensive Scheme in production engineering, and as a result, its students will be the first in the country to obtain the Higher National Certificate in Production Engineering.

Our Advisory Committee in conjunction with the City and Guilds of London Institute on Machine Shop Engineering (Machinists', Turners' and Fitters' Work) have revised this examination syllabus extensively, and steps are being taken with a view to providing incentives for craftsmen to take up this course in much greater numbers.

Appointment of Assistant Secretary (Technical)

Mr. James F. Gibbons, A.M.I.P.E., A.M.I.Mech.E., A.M.I.Mar.E., has been appointed Assistant Secretary (Technical) and took up duty in August. Other senior personnel have also been added to the staff at Headquarters necessitated by the growing membership and activities of the Institution. Lieut. Marsden, who is serving in the Forces, remains Assistant Secretary.

New Local Sections

The Inaugural Meeting of the new Northern Ireland Section of the Institution was held in April, 1942, in Belfast. The Council was represented by Lord Sempill, Deputy-President. The occasion was an outstanding success. Authority has been given for forming a South Wales and Monmouthshire Section. The Inaugural Meeting will be held in Cardiff in October.

ANNUAL REPORT AND ACCOUNTS

BUILDING AND DEVELOPMENT FUND INVESTMENTS, at cost :					
Loan to H.M. Treasury (free of interest).....	1050	0	0		
3% Defence Bonds.....	1000	0	0		
				2050	0 0
LEASEHOLD PREMISES SINKING FUND POLICY				508	13 4
DILAPIDATIONS RESERVE FUND POLICY.....				100	0 0
SUNDRY DEBTORS AND DEPOSITS.....				863	18 11
SUBSCRIPTIONS IN ARREAR, <i>not valued</i>					
CASH : At Bank.....	330	4	0		
At Post Office Savings Bank	1021	17	6		
In Hand.....	27	7	8		
				1379	9 2
AMOUNT DUE FROM RESEARCH DEPARTMENT per Contra.....				250	0 0
RESEARCH DEPARTMENT : Laboratory Plant and Furniture at cost, <i>less</i> amount written off				1196	18 1
Stock of Publications, <i>not valued</i>					
Sundry Debtors and Payments in advance				21	18 0
Cash at Bank and in hand.....				2012	15 0
				£39563	4 6

£39563 4 6

AUDITORS' REPORT.—We have audited the above Balance Sheet dated 30th June, 1942, and we have obtained all the information and explanations we have required. The Australian Section accounts are not included in the above Balance Sheet. Subject to the foregoing, in our opinion such Balance Sheet is properly drawn up so as to exhibit a true and correct view of the state of the Institution's affairs according to the best of our information and the explanations given us, and as shown by the books of the Institution.

Aldwych House, London, W.C.2.

9th September, 1942.

G. E. BAILEY,
President.

N. KIPPING,
Chairman of Council and Finance Com.

(signed) GIBSON, APPELBY, & Co., Auditors,
Chartered Accountants.

R. HAZLETON,
General Secretary and Treasurer.

THE INSTITUTION OF PRODUCTION ENGINEERS

INCOME AND EXPENDITURE ACCOUNT FOR THE YEAR ENDED 30TH JUNE, 1942

[illegible]

ANNUAL REPORT AND ACCOUNTS

" A.R.P. Fireguard Expenses	143	0	0
" Miscellaneous	89	19	11
" Transfer to Leasehold Premises Sinking Fund	127	3	4
" Transfer to Building and Development Fund	1000	0	0
" Amount written off Furniture, Fittings and Plant	51	14	10
" Amount transferred to Research Department Account	6004	11	0
	14818	10	1
" Balance, being Excess of Income over Expenditure	513	4	6
	£15331	14	7

 £15331 14 7

RESEARCH DEPARTMENT

*Third Annual Report of the Executive Committee of the
Research Department and Annual Accounts of the
Department for the Year Ended 30th June, 1942,
Presented by the Finance Committee.*

Growth of the Department

WE are pleased to be able to report satisfactory progress during the year under review. The publication in March, 1942, of the Report on Surface Finish marked a definite stage in the most extensive research work so far undertaken by the Department. Part II of Acceptance Test Charts for Machine Tools has now been published, and three important researches (two of which were of a confidential nature), have been completed for Government Departments.

Progress has also been reflected in the acquisition of some much-needed equipment and in additions to the number of the staff. There has been a very welcome increase of income. Income for the year to June 30, 1942, was £6,005 compared with £2,805 for the previous year. It would have been possible to secure an even larger income, but at this stage, unless income is expended during the financial year in which it is collected, taxation has to be paid on any surplus larger than the grant received by the Department from the Institution itself. This grant amounted to £1,543 for the year ended June 30, 1942. The surplus for the year was £1,204. If a grant-in-aid of our research from the Department of Scientific and Industrial Research is arranged, it is hoped that this taxation obligation will disappear.

Relations with the D.S.I.R.

Application was made during the year for a grant-in-aid from the D.S.I.R. and a deputation from the Institution, headed by Mr. G. E. Bailey, President, discussed the matter with representatives of the D.S.I.R. in February. Both the Council of the Institution and the Standing Committee of the Research Department unanimously decided that the D.S.I.R. proposals were unsatisfactory. Those proposals departed widely from the basis for financial aid previously under consideration between the Institution and the D.S.I.R. We were much disappointed at this turn of events, but feel confident that the growth and development of our research work will

RESEARCH DEPARTMENT ANNUAL REPORT AND ACCOUNTS

before long bring about the co-operation which, for our part, we are anxious to see established.

Equipment

As regards certain necessary equipment, we have found the appropriate Government Department most helpful. Difficulties about equipment have been a problem, but we hope that the growing importance to the war effort of the work being done in our laboratory will make it possible to overcome the difficulties.

The Research Plan

Great attention has been given during the year to the future work to be undertaken by the Department. A comprehensive report dealing with this and with work recently carried out, has been approved by the Council and the Standing Committee. The document entitled "The Research Plan" is circulated with this report. It covers to so large an extent material which otherwise would go into our present report that, instead of duplicating the material here we bespeak for that document the earnest attention of everyone interested in production engineering research.

Compression of Bushy Steel Turnings for Transport

Since the Research Plan was drawn up a report has been published (see *The Technical Bulletin*, No. 15, August, 1942) on an investigation carried out regarding the compression of bushy steel turnings to facilitate transport. This work was carried out at the request of the Research and Development Department of the Ministry of Supply.

Work in Progress

This includes the following, apart from work outlined in the Research Plan:

(a) An investigation into the cutting capacity of substitute steel "66" covering particularly single point cutting tools for lathes and planing machines and twist drills.

(b) An investigation into possible developments of cemented carbide tools for the fine finishing operations on ferrous and non-ferrous metals, and a comparison with diamond tools. Cemented carbide tools need little tungsten. The tip for a tool of 1 in. by $\frac{5}{8}$ in. shank weighs about 5 gm., 80% of which (12 gm.) is tungsten. The solid 18% tungsten tool weighs 1 $\frac{1}{2}$ lb., of which 4.3 oz. is tungsten. There is room here for a very big saving.

(c) An investigation into the efficiency of "66" material compared with the 18% tungsten material and the cemented carbide, covering roughing tests as well as finishing tests.

THE INSTITUTION OF PRODUCTION ENGINEERS

(d) An investigation into cutting tools for non-ferrous metals, particularly aluminium alloys, where very high speeds are called for. The equipment for this research has been designed and made in our laboratory.

(e) An investigation into the cutting compounds and their effects in relation to the above researches.

Subscribers to the Work of the Research Department

We acknowledge, with thanks, the following subscriptions for research received during the financial year and up to the time of the issue of this report :

	£	s.	d.
John Lund, Ltd.	26	5	0
Hepworth and Grandage, Ltd.	25	0	0
Associated Equipment Co., Ltd.	100	0	0
B.S.A. Tools, Ltd.	50	0	0
George Bray and Co., Ltd.	50	0	0
Vauxhall Motors, Ltd....	100	0	0
British Thomson Houston Co., Ltd.	250	0	0
G. Beaton and Sons, Ltd.	26	5	0
Leyland Motors, Ltd.	50	0	0
Standard Telephones and Cables, Ltd.	100	0	0
George Kent, Ltd.	25	0	0
Hoover, Ltd.	250	0	0
Climax Rock Drill and Engineering Works, Ltd.	100	0	0
Parnall Aircraft Co., Ltd.	100	0	0
W. P. Butterfield, Ltd.	10	0	0
A. C. Wickman, Ltd.	26	5	0
Catmur Machine Tool Corporation, Ltd.	52	10	0
Cutanit, Ltd.	50	0	0
Murex, Ltd.	100	0	0
Dennis Bros., Ltd.	25	0	0
Newton Chambers and Co., Ltd.	100	0	0
Black and Decker, Ltd.	10	0	0
Humber, Ltd.	50	0	0
Holman Bros., Ltd.	50	0	0
Thomas Ryder and Son	20	0	0
G. D. Peters and Co.	50	0	0
Reavell and Co., Ltd.	26	5	0
T. H. and J. Daniels	25	5	0
Aladdin-Industries, Ltd.	25	0	0
Wallace and Tiernan, Ltd.	5	5	0
Leytonstone Jig and Tool Co., Ltd.	5	5	0

Carried forward ... £1,883 5 0

RESEARCH DEPARTMENT ANNUAL REPORT AND ACCOUNTS

<i>Brought forward</i> ...				£1,883	5	0
Brush Electrical Engineering Co., Ltd.	...	...	...	52	10	0
Edward Pryor and Sons	...	...	...	20	0	0
H. M. Hobson Components, Ltd.	...	...	...	21	0	0
Ferranti, Ltd.	...	...	...	52	10	0
British Northrop Loom Co., Ltd.	...	...	...	10	0	0
Albion Motors, Ltd.	...	...	...	100	0	0
J. E. Baty and Co.	...	...	...	26	5	0
Jackson Boilers, Ltd.	...	...	...	5	5	0
Robey and Co., Ltd.	...	...	...	50	0	0
Adamant Engineering Co., Ltd.	...	...	...	26	5	0
Cooksedge and Co., Ltd.	...	...	...	10	0	0
W. Asquith, Ltd.	...	...	...	26	5	0
Hobbies, Ltd.	...	...	...	5	5	0
Glacier Metal, Co.	...	...	...	25	0	0
W. B. Dick and Co., Ltd.	...	...	...	5	5	0
British Timken, Ltd.	...	...	...	25	0	0
R. J. H. Equipment Co., Ltd.	...	...	...	5	5	0
Westland Aircraft, Ltd.	...	...	...	10	10	0
Birmid Industries	...	...	...	25	0	0
Thomas Firth and John Brown, Ltd.	...	...	...	250	0	0
Austin Motor Co., Ltd.	...	...	...	250	0	0
Metropolitan-Vickers Electrical Co. Ltd.	...	...	...	250	0	0
English Steel Corporation, Ltd.	...	...	...	250	0	0
Northern Aluminium Co., Ltd.	...	...	...	10	0	0
Sterling Engineering Co., Ltd.	...	...	...	100	0	0
Mollart Engineering Co., Ltd.	...	...	...	25	0	0
N. Davis	...	...	...	10	6	
L. Archer	...	...	...	10	0	
B. S. Lewis	...	...	...	10	0	
A. V. W. Fiddler	...	...	...	10	0	
A. H. Laycock	...	...	...	12	6	
C. B. Whittaker	...	...	...	5	5	0
F. W. Cranmer	...	...	...	2	10	0
N. Davis	...	...	...	10	6	
S. L. Harnett	...	...	...	1	1	0
W. H. Lowe	...	...	...	10	0	
Clarkson Engineering Co.	...	...	...	5	5	0
Boulton Paul Aircraft Ltd.	...	...	...	25	0	0
Howard and Wall, Ltd.	...	...	...	10	10	0
				£3,572	14	6

THE INSTITUTION OF PRODUCTION ENGINEERS

RESEARCH DEPARTMENT

BALANCE SHEET AS AT 30TH JUNE, 1942

		£ s. d.		£ s. d.	
LIABILITIES.				ASSETS.	
SUNDRY CREDITORS	286	8	5	PLANT AND EQUIPMENT at cost less amount written off:	
HEAD OFFICE	250	0	0	Balance at 1st July, 1941	525 19 4
INCOME AND EXPENDITURE ACCOUNT:				Additions during year ...	793 9 0
Balance at 1st July, 1941	1490	19	8		1319 8 4
Add Excess of Income over Expenditure for the year	1204	3	0	Less Depreciation	140 18 3
					1178 10 1
				OFFICE FURNITURE at cost, less amount written off:	
				Balance at 1st July, 1941	20 7 3
				Additions during year ...	4 3 6
					24 10 9
				Less Depreciation	6 2 9
					18 8 0

RESEARCH DEPARTMENT ANNUAL REPORT AND ACCOUNTS

STOCK OF PUBLICATIONS <i>not valued</i>		
SUNDRY DEBTORS AND PAY- MENTS IN ADVANCE		21 18 0
CASH :		
At Bank	1031 1 11	
Deposit Account : Bank	450 0 0	
Deposit Account : Post Office	500 0 0	
Petty Cash : Bank	31 6 1	
Petty Cash : In Hand ...	7 0	
		2012 15 0
	£3231 11 1	£3231 11 1

AUDITORS' REPORT.—We have audited the above Balance Sheet of the Institution of Production Engineers' Research Department dated the 30th June, 1942, and we have obtained all the information and explanations we have required. In our opinion such Balance Sheet is properly drawn up so as to exhibit a true and correct view of the state of the Department's affairs according to the best of our information and the explanations given us and as shown by the Books of the Department.

Aldwych House, London, W.C.2.
9th September, 1942.

G. E. BAILEY,
President of the Institution.

J. H. BINGHAM,
Chairman, Research Committee.

(signed) GIBSON, APPLEBY & Co., AUDITORS,
Chartered Accountants.

R. HAZLETON,
General Secretary and Treasurer of the Institution.

THE INSTITUTION OF PRODUCTION ENGINEERS

THE INSTITUTION OF PRODUCTION ENGINEERS
RESEARCH DEPARTMENT

Dr.	INCOME AND EXPENDITURE ACCOUNT FOR THE YEAR ENDED 30TH JUNE, 1942		Cr.
	£	s. d.	£ s. d.
To Salaries and Wages	2826	6 4	
" Management Expenses.....	500	0 0	
" Printing, Postages, Stationery and Telephone	66	7 1	
" Travelling Expenses	74	15 11	
" Professional Charges and Insurances	51	1 11	
" Technical Publications	889	18 5	
" Laboratory Materials	181	8 4	
" Repairs and Renewals to Plant and Equipment	11	17 0	
" Miscellaneous	48	7 3	
" Income Tax on Deposit Interest ..	3	4 9	
" Depreciation :			
Plant and Equipment 140 18 3			
Office Furniture	6	2 9	
	147	1 0	
	4800	8 0	
" Balance, being Excess of Income over Expenditure	1204	3 0	
	£6004	11 0	£6004 11 0
			</

THE RESEARCH PLAN

Report by the Research Committee of the Institution on Recent and Future Work of the Research Department.

1. Introduction.

With the approval of the Council of the Institution, we have adopted a plan of future work, prepared by our Executive and Finance Committees, and now put forward this plan together with a brief reference to the most important recent work of the Research Department of the Institution under the guidance of its Director, Dr. Georg Schlesinger.

2. Surface Finish.

The outstanding work so far carried out has been the research on Surface Finish, the Report* on which was published in March, 1942, two years after the preliminary report on the subject. The value of this research by Dr. Schlesinger is already fully recognised in the United States of America, while at home the British Standards Institution, on the publication of the Report, took immediate steps, at our request, to prepare a British Standard for Measuring Surface Finish, based on the Report. The British Standard, we understand, will be issued very soon.

The American Society of Mechanical Engineers informed us that it was deeply impressed by the Report and it put forward proposals, which we have accepted, for publishing it in the United States†. It also printed in the July issue of its publication, *Mechanical Engineering*, a long review of the Report by Mr. Stewart Way (Research Laboratories, Westinghouse Electric and Manufacturing Co.). The following are a few extracts from this review :

" Ever since the appearance of the Preliminary Report of the Institution of Production Engineers on Surface Finish, in *Engineering*, March 29, 1940, a great many production men and research workers in this country have been looking forward to publication of the complete Report Dr. Schlesinger's book is particularly welcome because it is one of the few books in the English language on the timely subject of Surface Finish

* Report on Surface Finish, March 1942. 15/6.

† The American Edition will be published on behalf of our Institution by the A.S.M.E., price \$3.25.

THE INSTITUTION OF PRODUCTION ENGINEERS

and because it brings together much new and hitherto unpublished information Much progress has been made in producing and measuring surface finishes. No small part of this progress has come about through the work of Dr. Schlesinger and his co-workers."

There then follow three columns devoted to reviewing the scientific and technical data covered in the Report and the recommendations made.

3. Other Work Already Carried Out.

We need hardly say that such immediate recognition of the importance of this part of our research work is very welcome to us, as it must also be to our Director. We owe to him and to his staff at our Laboratory no less than fourteen valuable reports that have been published on studies and researches into various aspects of production engineering since the Department was first opened in January, 1939. These reports include the following :

Cutting Tools, February, 1939.

Dial Gauge and Its Use, November, 1939.

Acceptance Test Charts for Machine Tools, Part I, March 1940.

Substitute Materials, August, 1940.

Modern Measuring Instruments, September, 1940.

Accuracy in Machine Tools : How to Measure and Maintain It, (second edition of 1,000, October, 1941).

The Rebuilding of Old Machine Tools for the Requirements of War, October, 1940.

The Natural Sag of Test Mandrels and Its Consideration in Checking Machine Tools, January, 1941.

The Influence of Warming-up on Capstan and Combination Turret Lathes, April, 1941.

The Effect of Reversing Flat Leather Belts, May, 1941.

Taps, Efficiency and Correct Design, June, 1941.

Materials, Cutting Tools and Machineability Index, February 1942.

Acceptance Test Charts for Machine Tools, Part II, March, 1942.

In addition to the reports mentioned, some research for individual firms as well as three highly important researches for Government Departments have been carried out. With the small staff and limited equipment available, the amount of work accomplished by our Department and its Director during three and a half years represents a considerable achievement.

4. The Production Engineer and Research.

Prior to the establishment of our Department little or no research into production engineering problems had been undertaken in this country since Professor Dempster Smith's work on Cutting Tools came to an end. This is remarkable considering the immense developments in technique during the past two decades, due in the main to improvements in machine tools and their accessories and to the growth of quantity production, accompanied by great strides in production management technique and in organisation methods.

To a large extent it was the production engineer who inspired these developments. Not being himself, as a rule, an inventor or designer, he had frequently no adequate means at his disposal for applying to the best advantage the results of scientific developments. In this sphere, as in so many others, science and invention threatened to outstrip the means available for their fullest application. Research was needed to help the production engineer to make the most of new machines, new materials, new processes and new methods. The purpose of our Research Department is to give him that help.

In carrying out that purpose we have found it necessary to proceed cautiously at the outset.

Finances* were not considerable; there was—and still is—widespread lack of comprehension of what is covered by production engineering research; the outbreak of war created many difficulties; and, finally, experience had to be acquired as to what could be achieved with the limited resources available. The time has now come, however, when, with the experience gained during the past three-and-a-half years to go on, we feel justified in adopting and putting forward for the consideration of our Affiliated Firms and the Engineering Industry in general the plan of future research work outlined in this report.

5. Scope of I.P.E. Research Work.

We have constantly borne in mind that the work our Research Department undertakes must have regard to what has previously been done, must avoid overlapping any work being done elsewhere, and must be strictly relevant to the sphere of production engineering.

Our Department, for instance, is not concerned primarily with

* In 1938 the Institution received a munificent gift of £25,000 from the then President, Viscount Nuffield. The Council applied £1,000 out of this to starting our Research Department and invested the balance. The full interest on these investments is placed at the disposal of the Department by the Council, as well as 80% of all membership subscriptions paid by Affiliated Firms on behalf of their Affiliates. Direct contributions for research are, of course, additional and are handed over in full to the Research Department. Firms are entitled to treat direct contributions as a trade expense for Income Tax purposes. The Income of the Research Department for the year ended June 30, 1942, was over £6,000.

the design of machine tools as such, but with their best use by the production engineer. Consequently the research into tests and alignments of machine tools has been undertaken from the user's point of view. Nor is it concerned with the development of new materials, but with the best way of treating and machining such materials.

Other examples of work within its scope are (i) the determination of the best cutting conditions for substitute cutting materials necessary for economy in tungsten, (ii) the selection of the best cutting fluids for increasing the life of cutting tools and improving surface finish, (iii) the determination of the most efficient cutting conditions for rough and finish machining of cast and extruded non-ferrous metals, etc.

In a recent specific case of national importance the result achieved by our Department was a reduction of cutting time to one-sixth, an increase of tool life five times greater than previously obtained and a reduction in the consumption of tungsten to one-hundredth of the original quantity.

In general, it can be said that developments in other branches of engineering, such as mechanical, electrical, metallurgical and chemical engineering, etc., which involve or affect production, may necessitate research to ensure optimum production under the changed conditions.

6. The Research Plan.

The plan of future work, put forward by our Executive and Finance Committees, which we have adopted with the approval of the Council of the Institution, covers the following :

- (a) LABORATORY RESEARCH.
- (b) SHOP AND PRODUCTION MANAGEMENT INVESTIGATIONS.
- (c) PRODUCTION ENGINEERING AND PRODUCTION MANAGEMENT INFORMATION SERVICE.

Before dealing in some detail with each of these heads, we may mention that our Executive and Finance Committees carefully considered the question of preparing a programme on a year-to-year basis. The difficulties in the way of doing so under existing conditions, however, made it undesirable to adopt such a basis, the reasons being :

(i) That the war introduces too many uncertainties as to finance, the acquisition of capital equipment, the possibilities of expanding laboratory accommodation, the appointment and reservation of staff, and the availability of materials.

(ii) That an annual programme is liable to be thrown out of gear by the necessity of undertaking urgent and unforeseen tasks. During the past year, for instance, a considerable pro-

THE RESEARCH PLAN

portion of the work of the Department was work undertaken at short notice for the Government.

Instead of a programme prepared on a year-to-year basis, therefore, we have adopted the Research Plan set out in this report covering the work which we propose to carry out as and when resources for doing so become available. The time it will take cannot be closely estimated. It is our intention to seek for the Plan the largest measure of support that can be obtained and to put the Plan into operation with energy and despatch.

(a) LABORATORY RESEARCH.

7. Optimum Performance of Tools and Machineability of Materials.

Cutting tests are of prime importance because increased efficiency of machining leads to increased output and reduced labour requirements. However good the design and materials available, ultimate success depends on efficient production. Efficient production, in its turn, must be based on optimum tool performance. Continuous development of tool performance is necessitated by changes in design of component and by development in cutting tool materials.

The research which it is intended to carry out into the maximum capacity of tools will cover :

(a) MACHINING MATERIALS BY CHIP CUTTING : MACHINEABILITY INDEX.

(i) *Tools.* Carbon steels ; high speed steels, including substitutes, *e.g.*, No. 66 ; high speed steels of various analyses ; cemented carbides ; diamonds, etc.

(ii) *Materials.* Ferrous : *e.g.* Cast iron, steel castings, mild steels, alloy steels. Non-ferrous : *e.g.* Aluminium, aluminium alloys, copper, copper alloys, light metals (magnesium alloys). Non-metallic materials.

(iii) *Machining Operations.* Turning, shaping (single point). Drilling (reaming, tapping). Milling. Broaching. Grinding (multiple point). Refining (lapping, honing, micro-finishing, super-finishing, etc.).

(iv) *Factors involved.* Tool life, power consumption and surface finish dependent on speeds, cutting angles, cross section of chip, coolant or lubricant, temperature and vibration.

(b) CHIPLESS FORMING.

Dies and punches for shearing, punching, forging, bending, drawing, ironing, coining, etc. Forces, power consumption, fly wheel action, influence of lubricants. Rigidity of standards, frames, etc.

(c) **MANIPULATION OF PLASTICS.**

Considerations of tooling as in (b) together with problems of trimming, trepanning, etc.

(d) **DIE CASTING AND FOUNDRY PRACTICE.**

Tools for die casting machines and fundamentals of foundry practice.

8. Further Research on Surface Finish.

Now that reliable methods of measuring surface finish have been determined it is necessary to apply them to production practice, *e.g.*, in the determination of the effect of cutting speed, feed, depth, tool dulling, etc., on surface finish in fine finishing operations, the comparison of ground and scraped surfaces, and alternative methods of producing surfaces of similar characteristics such as load carrying capacity.

9. Acceptance Test Charts for Machine Tools.

It is proposed to finish the work on Acceptance Test Charts undertaken by our Department. Parts I and II have already been published jointly by the Institution of Mechanical Engineers and our own Institution.

10. Performance of Shop Materials and Equipment.

It is proposed to undertake research into the performance of shop materials and equipment, covering such matters as coolants, lubricants, V-belts, chains and gears, etc., insofar as they affect production engineering.

11. Vibration in Machine Tools, Tools and Workpieces.

Carbides, diamonds and other modern cutting tools demand high cutting speeds for efficient operation. The introduction of high spindle speeds is accompanied by increased centrifugal forces, and vibration due to lack of balance. Such vibration, whether it originates in the tool, machine tool, or workpiece often has a profound effect upon the finish produced and the efficiency of the cutting operation. A grinding spindle, *e.g.*, may have to grind bores, perfectly cylindrical and accurate to 0.0001 in. while running at 60,000 r.p.m. These problems will form the subject of investigation.

12. Damping Capacity of Various Materials, and Design of Tools and Machine Tools as they affect Machining Processes.

Selection between cast iron, fabricated, concrete and other designs for machine tools need investigation based upon tests closely related to the machining operations concerned. Similar problems are involved in the design of tools.

THE RESEARCH PLAN

13. Hardness and Resistance to Wear.

It is intended to study the performance of machine tools, tools, gauges, etc., which are closely connected with the hardness and resistance to wear of the materials used. Selection of materials and their surface treatment is dependent upon a knowledge of the relation between these factors.

14. Bearings.

This research will include bearing design, selection of bearing materials, fits, type of lubrication, etc., necessary under the limitations of various production conditions.

ESTIMATED COST OF THE LABORATORY RESEARCH.

15. (a). We have had detailed estimates made of the cost of the above plan as regards machines, instruments, material and tools, based upon prices now prevailing. The estimate shows :

(i)	Capital cost of machines...	...	£9,400
(ii)	Capital cost of instruments	...	5,830
	Total capital equipment	...	£15,230
(iii)	Materials ... ..	...	3,400
(iv)	Tools ... ..	...	2,230
			<u>£20,860</u>

(b) Of the estimated capital cost shown above amounting to £15,230 we have already acquired (by purchases, gift or loan), machines and instruments to the value of £6,190, leaving machines and instruments to the value of £9,040 still to be secured.

(c) Other charges besides equipment, material and tools are more difficult to estimate. We have not yet fully examined, for instance, the cost involved by such increased laboratory accommodation as may be required. The question is being gone into. We would like once more to express our deep sense of obligation to the Board of Governors and the Principal of Loughborough College, Dr. Schofield, for the free use of the existing laboratory accommodation. Apart from the question of increased accommodation, however, the estimates furnished to us show that in a full year the complete laboratory plan would entail the following cost :

General charges ...	£600
Travelling ...	200
Publications ...	400
Management fee ...	300
Insurances, etc. ...	100
Personnel ...	8,500

£10,100 (excluding depreciation or
interest charges).

(d) In addition there would be depreciation charges. These would depend on capital expenditure on equipment and possible laboratory extensions. If we were to acquire on loan from the Machine Tool Control, Ministry of Supply, the balance of equipment needed for the plan, namely £9,000 at $12\frac{1}{2}$ per cent, this would represent an annual charge of £1,125. If the equipment has to be purchased, the depreciation charge would be £900 p.a. for ten years.

(e) When the plan, comes into full operation the annual cost of the laboratory section would be roughly as follows :

	£
Personnel	8,500
Materials (taken at one-third of total)	1,133
Tools (taken at one-third of total)	743
Charges set out in (c) (other than Personnel) ...	1,600
Depreciation (including present charges and on basis of $12\frac{1}{2}$ per cent for new equipment) ...	1,324
Rent or capital charges on extension of laboratory premises (not estimated)	—
	<hr/>
	£13,300

(b) SHOP AND PRODUCTION MANAGEMENT INVESTIGATIONS.

16. (a) Studies of shop and production management technique will cover problems such as the Preparation of Work, Works Loading, Production Control, Rate Fixing, Processing, Tooling, Jigging, Handling of Materials, Statistical Control, and other problems of shop management.

(b) The work to a considerable extent will be carried out by qualified field workers co-operating with outside factories. This will enable the Research Department to keep in close touch with production executives and get first-hand knowledge of some of the more urgent problems confronting production engineers. Field reports will form a basis for selecting tests to be carried out either in the laboratory or by the field workers themselves. The scope under this head is very wide and of great importance. For the purpose of our plan we suggest that about five competent workers be appointed.

(c) The cost of salaries and travelling expenses for this work is estimated at £4,000 per annum, and the cost of publishing reports might amount to £200—a total of £4,200 per annum.

THE RESEARCH PLAN

(c) PRODUCTION ENGINEERING AND PRODUCTION MANAGEMENT INFORMATION SERVICE.

17. (a) The Research Department already provides members, through the Abstracts in our monthly *Journal*, with information on production problems published in leading technical periodicals in this country, U.S.A., Australia and the Continent. It also answers questions submitted by correspondence from members and others.

(b) This service is capable of considerable expansion, particularly in such directions as the following :

(i) The creation of an up-to-date and fully indexed source of information on production engineering.

(ii) Assistance and advice (to members and affiliated firms) on problems which do not necessitate further research.

(iii) The development of production statistics.

(iv) The preparation of standardisation of materials, tools and other production equipment, standards for the drawing office and ratefixing department, *e.g.*, numbers of revolutions, speeds, feeds, cutting angles, etc.

(v) The compilation of Manuals for production executives such as production managers, inspectors, foremen, etc., on the development of tools, machine tools, processes and shop economics.

(c) The cost of this service we would place at £2,000 per annum, including the publication of at least one Manual every year.

18. Estimated Annual Cost of the Plan for a Full Year of Operation.

The estimated cost of the Plan for a full year of operation is :

Laboratory Research	... ..	£13,300
Shop and Production Management Investigations	...	4,200
Information Service	... ..	2,000
		<hr/>
		£19,500

LONDON, August 13, 1942.

SURFACE FINISH

Report of the Research Department of the Institution of Production Engineers, 36 Portman Square, London, W.1.

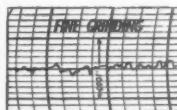
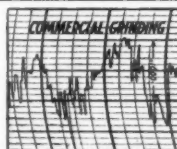
by DR. GEO. SCHLESINGER, *Director.*

January, 1942

Price 15s. 6d. nett (For members 10s. 6d.) Copyright

CONTENTS

Principle factors involved. Results of measurements. The influence of the scratching action of the stylus of tracer instruments. (a) Classification of surfaces without measurement. (b) Quantitative photomicrography. Dimension and surface roughness of gauges. The instruments used. Investigation of surface roughness in the U.S.A.



Showing
Quality of Surface
and Manufacturing
Process.

Review from MACHINERY—England, April 16, 1942.

The subject of surface finish in relation to dimensional accuracy, fit, lubrication and wear of operational components has been one of the most important questions that have occupied investigators in recent years on both sides of the Atlantic.

One of the chief problems has been the quantitative determination of the amount and conditions of surface finish and a unit of roughness.

The results presented in the report make a most important contribution to the development of a technique of basic importance in engineering production, and, in a remarkable table occupying 48 pages, the findings are collected and compared in respect to 500 surfaces of all kinds.

The aims of the research, the chief of which was to replace the loose descriptive methods by a more definite system for measuring surface roughness, appear to have been completely reached.

Review from ENGINEERING—July 24, 1942.

The importance of the matter, and, no doubt the very complete basis for a consideration of the subject which is furnished by this report, has led to the appointment of a committee of the British Standards Institution to consider the formulation of standards.

For the purposes of this investigation the Institution appealed to a wide range of manufacturers of the finer grades of engineering product and obtained typical specimens of finished work from 19 British firms. The most important instruments, both for the measurement of surfaces and for their comparison, were also lent by British and American makers.

Those who have hitherto given little attention to the matter will find the report an admirable guide to the whole subject of surface finish.

Review from AIRCRAFT PRODUCTION, May 1942.

Although engineers have realised for some considerable time the importance of the quality of surface finish for both moving and static parts, practical engineering data and technical literature have not hitherto been available for those interested. Consequently the Research Department of the Institution of Production Engineers are to be congratulated on their foresight in making the first thorough investigation of the subject in this country. The results of the experiments have been collected and arranged as practical, useful measuring units in a table giving data describing approximately 500 surfaces of all types. The instruments used for measurement included the most modern tracer and optical apparatus.

Review from MECHANICAL ENGINEERING—July, 1942 (American Society of Mechanical Engineers).

Dr. Schlesinger's book is particularly welcome because it is one of the few books in the English language on the timely subject of surface finish and because it brings together much new and hitherto unpublished information.

The study was undertaken to provide standards for the measurement and rating of metal surfaces and to summarise standard practice in Great Britain as regards the type of finish which is applied to various machine parts by reputable manufacturers.

The tabulation of the results of these measurements in the last 48 pages of the book is one of its most valuable features.

One of the most interesting sections of the book deals with the tolerances and finishes on plug and snap gauges and on gauge blocks. The finish measurements on these tools are quite enlightening.

STEWART WAY, *Research Laboratories, Westinghouse Electric Mfg. Co., East Pittsburgh*

HEAT TREATMENT

*Paper presented to the Institution, Sheffield Section,
by D. C. Harries, B.Met.*

I DO not think an audience of Production Engineers needs to be reminded of the tremendous part played by Steel in the world to-day, whether we consider the very varied and exacting calls of peace time or the more vital demands of War time.

The plain carbon steel has a very wide but a definitely restricted field of usefulness, and were we solely dependent upon this, the simplest type of steel, we should certainly not witness the high speeds, pressures and temperatures which characterise the engineering world as it exists at the present day. We have to call in the aid of the alloy steels, therefore, to supply the missing links, so to speak, in a long chain of physical properties, which can be adjusted in quite a remarkable way to the manifold needs of engineering science.

What is the secret of this very versatile character of steel? Its capacity to take up alloying elements is only a part of the story. The essential point is that steel undergoes certain transformations or structural changes on heating to a red heat, more precisely to a temperature slightly above its so-called "Critical range." Now whilst there is a natural tendency for these changes to take place in the reverse order on cooling sufficiently slowly, they can be suppressed to a greater or less extent, depending upon the chemical composition, by increasing the rate of cooling.

This business of ringing the changes upon the structure, and hence the physical properties of steel, by heating to and cooling from suitable temperatures, constitutes what we commonly understand by the term "Heat Treatment."

I would like to spend a little time with you in considering some of the fundamental principles involved in this process. If we start at the beginning and consider the behaviour of Iron, which after all is the base of all steel, we find that in its pure state iron is soft, actually about as hard as copper with a tensile strength of the order of 18 to 20 tons per sq. in.

It remains soft even when quenched, say, from 1000°C. or for that matter after any form of heat treatment whatsoever.

It follows, therefore, that it is only by adding other constituents, notably carbon, that we are able to get the hardness we commonly associate with steel. Iron and carbon can unite to form a very

hard and stable compound called iron carbide, or cementite, and it is in this form that carbon is present in cold steel. A plain carbon steel, then, is essentially composed of two constituents, one soft, namely iron, and the other hard, namely iron carbide. As can be readily imagined, the way in which this hard constituent is distributed in a background of comparatively soft and ductile material will largely determine the physical properties of the mass as a whole—the finer and more uniform the state of dispersion of the carbide the better the properties. For a given steel the structure, and therefore the physical properties determined by it, can be controlled by heat treatment, as will be shown presently.

What is the particular characteristic of iron which makes this possible? Pure iron undergoes certain changes on heating, and the reverse series of changes on cooling. For instance, at 900°C . there

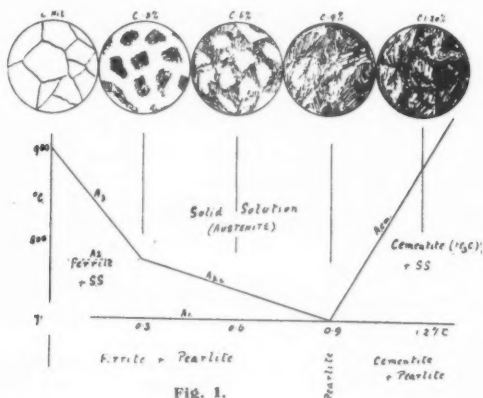


Fig. 1.

is a change in its atomic structure such that at temperatures above this, iron is capable of holding iron carbide and other carbides in solid solution, whereas the form in which iron exists below 900°C . possesses this property only to a very minute extent. This means that a piece of ordinary carbon steel at, say, 900°C . would have a perfectly homogeneous structure something like a pure metal, and if no change occurred during cooling to atmospheric temperature, we should always have, whatever the rate of cooling, a perfectly homogeneous alloy with a comparatively low tensile strength and a high ductility. Such we know is not the case, but on the contrary, for the reason just given, the so-called solid solution of iron and iron carbide present at an elevated temperature breaks down into its separate constituents at some lower temperature.

Now let us take a brief glance at the lower half of the iron-carbon thermal equilibrium diagram (see Fig. 1) which maps out the changes which take place in a series of steels of varying carbon content, when very slowly heated or cooled. Follow the upper line of the diagram which forms, roughly, a "V," the bottom of which corresponds to 0.9% of carbon. Notice as you move from left to right, that the change occurring at 900°C. in pure iron, to which we have already referred, is progressively lowered by increasing carbon content up to 0.9% carbon, after which it rises again. At temperatures above the "V" the two constituents, iron and iron carbide, are in mutual solid solution, as a homogeneous alloy.

Now let us take a typical case of a 0.3% carbon steel cooling from some temperature above the "V," that is, above its upper critical point which for a steel of this composition occurs at 810°C. At 810°C. the solid solution begins to break up though the process is not complete until a temperature of about 700°C. is reached, corresponding to the horizontal line at the bottom of the diagram. The commencement of the change at 810°C. is marked by an evolution of heat or recalescence, and a corresponding small increase in volume, as iron or ferrite begins to separate itself from the solid solution. Iron continues to separate until the horizontal line at approximately 700°C. is reached, when the remaining solid solution, which has been drained of iron to such an extent that it now contains 0.9% carbon, breaks up into a eutectoid mixture of iron and iron carbide which is called pearlite. This completion of the transformation is accompanied by a further evolution of heat and a corresponding expansion larger than the previous one. The resultant structure would approximate to that shown on the second diagram from the left, at the top of Figure 1. The white constituent is iron and the grey constituent pearlite.

This diagram shows that under conditions approaching equilibrium, the critical change commences at different temperatures according to the amount of carbon present, but that in all cases the change is completed at approximately 700° C. On heating the changes take place in the reverse order, being accompanied this time by an absorption of heat and a decrease in volume.

Since there is a time interval involved in these changes, it follows that the more rapidly the steel is cooled the less chance there is for its two constituents to separate so completely. Take for instance, a 0.6% carbon steel in the form of 1 in. dia. bar. If it were possible by extremely rapid cooling, to suppress completely all critical changes, one would retain a soft and ductile homogeneous structure, but it is impossible to do this. Let us then consider the same sample when quenched in water. The solid solution would break down, but the two constituents would be so finely intermixed that they

could not be distinguished separately under the microscope. Under these conditions the hard carbide constituent would have the maximum stiffening effect upon the soft iron background, and the result would be extreme hardness, with little or no ductility, typical of certain plain carbon steel cutting edges, or say, the flame hardened teeth of a pinion in a steel of this composition.

If steel in such a condition were now tempered, which means heated to some temperature below the lower limit of the critical range, there would be a progressive separation or growth of ultra-microscopic carbide particles as the temperature rose, accompanied by a steady reduction in hardness and brittleness and a corresponding increase in ductility. The effect of tempering begins at about 200° to 300° C., but for all-round properties the best tempering range, as we shall see later lies between 600° and 650° C.

There is another aspect of the structure of iron-carbon alloys which has a bearing on the operations of full annealing and normalising. The structure of steel in the "as cast" or "as forged" state is coarse, that is to say, the individual crystals or grains which make up the mass are large. As a steel ingot after solidification, or after forging, cools through the critical range, the separation of the constituents, ferrite and pearlite, takes place around and within this coarse crystalline framework. Now when such an ingot or forging is reheated to a temperature just above the upper limit of the critical range, the solid solution thus formed, as previously explained, is not composed of a fresh set of much smaller crystalline grains. Heating to still higher temperatures would progressively coarsen this refined structure, an effect intensified also by prolonged soaking at these higher temperatures. From all points of view the coarse structures typical of the "as cast" or "as forged" conditions are undesirable, and in consequence we find it necessary to anneal or normalise in order to produce a refinement of these structures.

Slides were put on the screen to illustrate some of the following points :

1. 0.3% carbon steel, 'as cast.' Note the massive ferrite or pure iron (the white areas) openly spaced, actually forming a sort of lattice pattern. This is a structure typical of slow cooling from the molten state.

2. The same steel improperly refined. Notice the remains of the coarse lattice pattern which denote that the annealing or normalising temperature has been low.

3. The same steel effectively normalised. A structure typical of a Ship Shaft or Boiler Drum with a tensile strength of about 36 tons per sq. in.

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4. The same steel oil hardened and tempered, the structure denoting a tensile strength slightly higher than that of the normalised steel, but still below 40 tons per sq. in., as may be judged by the relatively large areas of separated ferrite.

5. 0.5% carbon steel, water quenched and tempered, probably in the form of a bar of about 1 in. section. Notice the uniformity of structure, with absence of any separate masses of free ferrite. The carbide, here, is exerting considerable stiffening effect on the

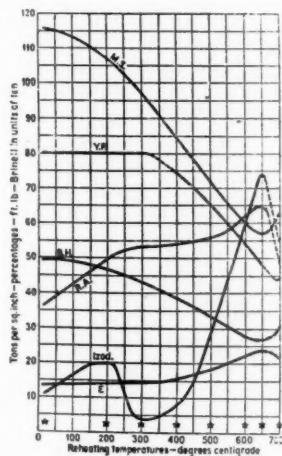


Fig. 2

iron background. This structure is typical of this steel treated to give maximum all round mechanical properties with a tensile strength of, say, 55/60 tons per sq. in.

6. Globular Pearlite. This type of structure is obtained by prolonged soaking at a high tempering temperature. The carbide particles have not only separated but coalesced into spheroids, and as such will not exert much stiffening effect. The structure denotes softness, ductility, and ease of machining, but is otherwise of no great use in service. Incidentally, this structure is frequently met with in ball race steel; in fact, it is deliberately produced by prolonged tempering, in order to facilitate automatic machining and subsequent uniformity of hardening.

7. (See Fig. 2). A typical series of tempering graphs, illustrating the effect of tempering after hardening. Notice the progressive lowering of Maximum Stresses, Yield point and Brinell Hardness and the corresponding raising of the Elongation, Reduction of Area and Izod Impact Value.

I wish now to pass on and deal very briefly with the purpose of adding special alloying elements such as Nickel, Chromium and Molybdenum, etc., and to indicate how, from a treatment point of view, these resultant alloy steels (not including the more highly alloyed austenitic type) supplement the carbon steels. As we all know, there is a wide scope for plain carbon steels in fairly large sections in the normalised, or normalised and tempered, conditions having tensile strengths up to, say, 40 tons per sq. in.

Marine shafting, certain types of rotor and turbine shafts, large gear wheels rims, loco straight axles and crank axles are a few examples. Certain components of fairly generous section, calling for higher tensile strengths, say, up to 55 tons per sq. in.—as, for instance, railway rails, and tyres, and other miscellaneous items—can be satisfactorily catered for in carbon steel, but in general its application becomes less and less, in the higher ranges of tensile strength, as the section of the part increases.

Small sections such as files, taps and miscellaneous tools can be effectively hardened throughout, and in such cases the plain carbon steel can 'fill the bill.'

Perhaps the coming of the Motor Car was the single factor most responsible for the development of alloy steels on a wide commercial scale, for here the demand was for high tensile and fatigue strength, with reasonable ductility and ability to withstand shock stresses, throughout sections of fairly large mass.

We have seen that, in order to obtain the maximum combination of tensile strength, ductility and toughness, it is necessary to produce a microstructure of a certain type, in which the carbide exists in a fine state of dispersion and is evenly distributed throughout the background of iron, and that, in a plain carbon steel, which should contain at least 0.5 to 0.6% carbon, this entails quenching in oil or preferably water followed by tempering. The extent to which this is practicable must obviously depend upon the mass or section of the part. The outer layers will, of course, cool more quickly than the layers underneath, and if the rate of cooling at the centre is less than the so-called 'critical rate' necessary to produce the full hardening effect, there will be, naturally, a tapering off in structure and properties from the outside to the inside.

A steel such as a plain carbon steel which exhibits this so-called 'mass effect' in a marked fashion is therefore unsuitable where 'depth' of hardening is required. On the other hand, where the object is to confine the hardening effect to the outer layers and to prevent it spreading throughout, as in certain tools (chisels, etc.), advantage can be taken of this phenomenon.

(See Fig. 3.) These graphs illustrate the falling off in tensile strength, yield point, and particularly Izod impact, as the section

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increases, in this case from $\frac{9}{16}$ in. to 4 in. Each section has been water hardened and tempered at 600°C .

The rapid fall in the Izod toughness curve emphasizes not only the effect of increased mass, but also the necessity of discriminating between toughness and ductility. You can see that it is possible to have reasonable ductility with quite a low order of toughness. With the further observation that, quite apart from the effect of

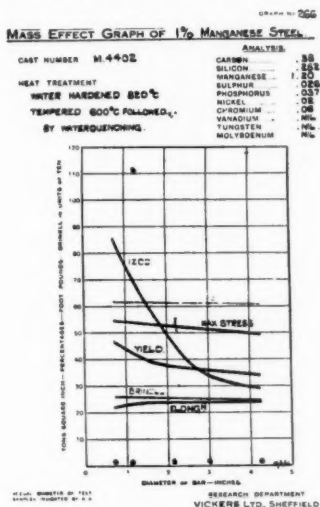


Fig. 3.—Mass effect graph of 0.38% carbon steel (containing 1.2% Manganese).

mass, the Izod values for carbon steels are generally erratic, particularly as the tensile strength increases, we will now consider how and why the additions of alloying elements tend to overcome these limitations. Elements such as chromium, molybdenum, tungsten, vanadium, etc., are like iron in that they form carbides, some of them, particularly those of tungsten and vanadium, being exceptionally stable. They, together with nickel, can also go into solid solution with iron.

The structural alloy steels are like the carbon steels in that they can be regarded as having only two ultimate constituents, but in place of a simple iron carbide we now have a complex carbide, and in place of iron we have an alloy or solid solution of, say, nickel and chromium in iron. Now at temperatures above the critical range these elements and carbides form a very stable solid solution with iron, which on cooling decomposes much more sluggishly than

is the case with plain carbon steels. As a consequence of this, so it would seem, the transformation changes on cooling occur at considerably lower temperatures, the more so as the amount of added elements and the cooling rate are increased.

The great practical significance of this, is that the 'critical rate' of cooling, i.e., that which is necessary to secure the full hardening effect in these steels, is much lower than for the carbon

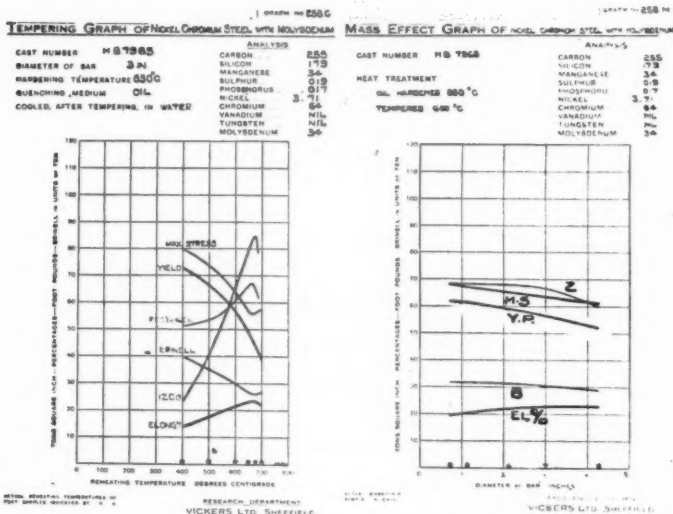


Fig. 4

Fig. 4.—Typical tempering curves for a nickel chromium molybdenum steel, oil hardened and tempered at 600°C.

Fig. 5.—Mass effect graph for the same steel; $\frac{1}{2}$ " to 4" section.

steels, from which it naturally follows that for a given rate of cooling of type of quench, a greater 'depth' of hardening is obtained. Further, as the amount of alloying elements, particularly in certain combinations, is increased, we come to a point where full hardening is obtained by cooling relatively large bars in air, giving us the so-called air hardening steels.

A typical air hardening steel would contain 0.3% carbon, 4 to 4½% Nickel and 1 to 1½% of Chromium. Between this and the carbon steels we have a host of less highly alloyed steels, which, even in quite large masses, can be hardened throughout by cooling in oil. In a word, the effect of the added alloying elements is to overcome the 'mass effect' which is such a strong characteristic of plain carbon steels.

Perhaps molybdenum deserves special comment, in that quite a small amount, say 0.3%, when added to a typical nickel-chrome steel containing about 3% nickel and 0.5 to 0.7% chromium, overcomes the tendency to what is known as Temper Brittleness which is sometimes found in ordinary nickel chrome steels, and tends generally to make the steel more foolproof under varying conditions of heat treatment. Its effect is still more marked up to 0.6% in reducing still further the mass effect, with special reference to the Izod Impact value.

A steel of this composition is not entirely without some 'mass effect', as can be judged by the gradual reduction in maximum stress and yield point with increasing section, but notice particularly the flatness of the Izod curve which is in marked contrast to the Izod curve of plain carbon steel which was shown in Figure 3. You can see that it is possible to obtain over 60 tons tensile strength with an Izod value of over 60 ft.-lbs., in a bar of 3 in. diameter, which of course would be quite impossible in a carbon steel.

We have discussed thus far the structural alterations which can be brought about in steel by heat treatment and how these affect the mechanical properties, also the natural limitations of heat treatment as applied to carbon steels and how these can be overcome by the addition of alloying elements.

The processes of heating and cooling steel of different compositions in different shapes and sizes are attended by many difficulties, many of which are caused by stresses set up both by temperature gradients and by volume changes taking place at different times at different places in the mass. Now I do not wish to go into this very complicated subject in any great detail, but merely to indicate broadly some of the precautionary measures which should be taken to keep these stresses within safe limits.

When steel is heated and cooled it undergoes normal expansion and contraction, but in addition, as it passes through its transformation changes, it experiences volume changes in the reverse direction. That is, on heating the critical change is accompanied by a contraction, and on cooling by an expansion.

Although the two kinds of volume changes are necessarily inseparable in practice, it can be said that these associated with the critical points constitute the greater problem. If all the factors relating to heating and cooling operations be considered, and particularly if it be borne in mind that the critical change of the usual alloy steels will take place at much lower temperatures on cooling than on heating, it will be evident that the cooling process is the one fraught with the greater danger. Distortion, clinks, hardening cracks, haircracks, etc., are all due to stresses set up during heat treatment.

Let us take the heating operation first. Now when a steel ingot or forging is heated from cold, in the initial stage there will be, naturally, a temperature gradient from outside to inside; the hotter the furnace at the time of charging, the steeper the temperature gradient. The outside layers will want to expand but are prevented from doing so by the, as yet, relatively cold interior. Stresses are therefore set up in the mass of steel. Actually, the outer envelope is being held back by the inside and is therefore in a state of compression, the inside being in tension. If the net result of these stresses is in excess of the yield point of the steel, the section might conceivably rupture or 'clink.' This rarely, if ever, occurs; but, so far as the heating operation is concerned, the initial stages, up to, say, $500^{\circ}\text{C}.$, are the most important, particularly where large masses are concerned. Hence, preheating ingots for rolling or forging is frequently carried out in a continuous type of furnace with a temperature gradient in an upward direction from the charging end. Whenever possible, hollow trepanned billets of considerable section, for subsequent hollow forging, are even steam warmed before preheating.

Similar precautions are necessary in heating the resultant forgings for hardening or normalising, the initial stages receiving the most consideration from this particular angle. Uneven heating, which is frequently the result of too rapid heating, will often cause forgings, whose cross-section is small compared with their length, to distort or 'pull' in the furnace.

As the temperature rises, as is well known, steel gradually loses its elastic properties and at about $500^{\circ}\text{C}.$ its elastic limit is very low. Internal stresses will now begin to dissipate themselves by plastic movement, or 'creep,' and from this point onwards heating may be continued comparatively rapidly, until the desired temperature is attained. The steel passes through its critical change, say, between $700^{\circ}\text{C}.$ and $900^{\circ}\text{C}.$, accompanied by a small contraction, but this is easily catered for by the plasticity of the steel at these temperatures.

At actual normalising or hardening heats, over $800^{\circ}\text{C}.$, the tensile strength of steel is, of course, low and actual 'sagging' will take place in sections which are long in relation to their diameter, a ship shaft for example. This is where trouble and care to balance the jobs on their supports beforehand is well repaid.

On cooling, whatever the medium be, furnace, air, oil or water, we shall have the outer layers cooling more rapidly than the interior, wanting to contract but prevented from doing so by the interior—a case of a number eight shoe on a number nine foot. If the cooling is not uniform all round the section will bend or distort, or if it does not distort at once it may do so during subsequent machining, because, the internal stresses left in the section

have not been symmetrically arranged. So far as the stresses caused by normal expansion and contraction are concerned, the great secret is to ensure that the stresses are symmetrically arranged about the axis by controlling the conditions so that the heating and cooling is as symmetrical as possible, and that the stresses are kept to a minimum by heating and cooling as slowly as practicable. Forgings of irregular section naturally present a greater problem than those of uniform section, and, in consequence, demand special care.

Now the critical change points on cooling, as already stated, may occur at comparatively low temperatures, particularly in alloy steels, generally speaking the more so as the rate of cooling is increased. The steel is undergoing a normal process of contraction, when it is called upon to accommodate an expansion. In plain carbon steel this may take place, during normalising and annealing, at temperatures between, say, 700°C. and 600°C., when the steel is in a semi-plastic condition, capable of adjusting itself to these stresses.

In an alloy steel, as for instance a typical oil hardening nickel-chromium-molybdenum steel, cooling slowly from, say, 850°C., the critical changes are depressed and may occur somewhere between 450°C. and 350°C., when the steel has become comparatively rigid, and is less able to accommodate them on this account. Moreover, as steels of this type are not entirely free from 'mass effect' under conditions of somewhat faster cooling, say in air or oil, we have a gradient of structure from outside to inside with a corresponding difference in the magnitude of the accompanying volume changes.

Quite a complicated system of stresses may be brought about by different conditions, and when these are superimposed on the normal contraction stresses, the effect may be sufficient to cause a hardened roll to 'clink' or a bar to crack longitudinally. When considering the various precautionary measures which can be applied to the cooling operation, one has to take into account not only the problem of material delivered 'hot' to the Treatment Plant from the Forge or Rolling Mills, but also the troubles concomitant with later operations such as normalising and oil or water hardening.

The plain carbon steel, as you may have already gathered, does not present a very great problem. The lower carbon steels, provided of course that the mass of the section is not excessive, may be cooled right out on the 'shop floor,' otherwise it is usually sufficient to charge into a furnace standing at 650°C. or so, preferably make uniform at this temperature and cool in the furnace at some given rate, dependent upon the mass.

For large ingots or billets of 50 in. diameter or upwards, it is often found advisable to arrest the cooling by a series of 'steps,' as shown by the first graph in Figure 6, to ensure that the tem-

perature gradient from outside to inside is kept down to a minimum. For the alloy steels, as already stated, we have to provide against critical volume changes which now occur in a lower temperature range. It is essential that the cooling rate while the material is undergoing these changes, within the range of, say, $450^{\circ}\text{C}.$ to $350^{\circ}\text{C}.$, should be considerably slower than is necessary for the carbon steels, that time should be allowed for these changes to complete themselves by holding at a temperature just below the lower

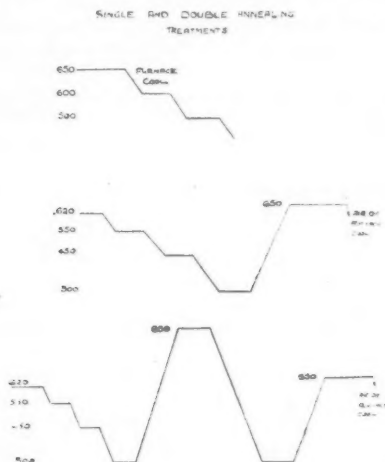


Fig. 6.

critical point, and that this should be followed immediately by re-heating to, and soaking at, a full tempering heat for the particular steel in question. This gives us the so-called 'up and down' double anneal illustrated by the second graph in Figure 6. 'Steps' have been introduced into the first cooling operation during which the steel will have its critical volume changes superimposed upon the normal process of contraction, and in order to make sure that the cooling rate during its most vital period is sufficiently slow, it is obviously necessary to ensure that the temperature gradient throughout the mass before reaching this period shall not be great. If, instead of following this by a further soaking at $650^{\circ}\text{C}.$ we allowed the material to cool right out, the section would be left in a state of internal stress resulting from its critical volume changes, and this further cooling might give rise to the formation of haircracks. Moreover, where it is desired to carry

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out an intermediate machining operation at this stage, it would be found that the steel would not be in its softest condition. The purpose of the second part of the treatment, therefore, is to relieve stresses in the material resulting from its cooling, and to effect final softening. As no further transformations will take place in the steel on cooling from 650°C. this cooling may safely take place in air if the section of the forging is not unduly large.

Incidentally, if any mechanical straightening is required, it is both convenient and satisfactory to do it when this tempering is completed, and, if possible, to finish before the temperature falls below 450°C.

If in addition, it is required to introduce a full refining heat as, is often desirable, this can be easily done as shown by the third graph in Figure 6.

As regards cooling in certain media such as air, oil or water, followed by tempering for the express purpose of obtaining the mechanical properties, so far as the question of internal stresses is concerned the most we can do is to see that these are symmetrically arranged about the axis of the section by ensuring that the actual cooling is as uniform as possible. It is most essential, moreover, that the actual cooling does not go needlessly beyond the point where the transformation changes are complete before the final tempering operation is started.

For instance, if instead of cooling a typical 3½% nickel-chromium-molybdenum steel right out in oil the section is transferred for tempering at the earliest opportunity, which in practice is governed by the flash point of the oil, a considerable needless amount of additional internal stress is avoided.

Good practice should always pay due consideration to these factors, and indeed unless such has been the case, particularly with certain steels, the lesson can be brought home with considerable emphasis.

Whilst discussing treatments of this latter kind, often having the purpose of meeting quite stringent mechanical test specifications, one must consider such factors as quick transference from furnace to quench, the general effectiveness of the quench itself, and uniform and accurate temperature control, particularly during the tempering operation, as all these are factors which naturally affect the final result.

Discussion

MR. J. W. WALKER (Section President, who occupied the chair) : We are very much indebted to Mr. Harries for a very excellent lecture. He has gone over very carefully and fully the particulars underlying the operations in the treatment of steels, and I for one,

have learned quite a lot from what he has told us. One point which struck me, when it was mentioned, is that in spite of the fact that the elongation and reduction of area remain fairly constant in certain types of steel, as the mass increases, the Izod drops very considerably. It always occurs to the average engineer, that if the elongation is correct, a reasonably good impact value would be expected. Another point I had hoped Mr. Harries would explain is the effect of repeated tempering, which is normally carried out on cutting tools, for example, in high speed steels. We have heard of a firm who claim to make such steels 100% better by a special treatment. Can Mr. Harries give us any light on the treatment, and tell us whether it is caused by an increase in the number of tempers?

MR. HARRIES : Thank you, Mr. President, for your kind remarks. With regard to your question as to why in Carbon Steels, the Izod value falls away as the mass increases whilst the ductility remains fairly constant, perhaps this can be explained in terms of microstructure. Certain it is that the falling off in mechanical properties from the outside to the inside of any section exhibiting this phenomenon of "mass effect" is accompanied by a corresponding variation of microstructure. The desirable form of microstructure in which the carbide constituent is finely dispersed within the ferrite background, typical of, say a water hardened and tempered 0.5 carbon steel bar, will show a gradual tapering off from outside to inside. This gradient of microstructure, which is naturally more pronounced as the section is increased, is usually marked by an increase in the amount of 'free ferrite' towards the centre of the section where there has been more time for the two constituents, ferrite and pearlite, to separate from each other during the quenching operation. Now, the presence of increasing amounts of free ferrite from outside to inside evidently does not adversely affect the ductility or ability of the material to deform, and this is really not surprising but rather what would be expected. On the other hand, it would seem that the Izod value or ability of the material to resist the propagation of a crack does somehow depend upon the degree to which the hard carbide constituent is uniformly dispersed throughout and stiffens up the soft ferrite constituent.

With regard to the tempering or so called secondary hardening of High Speed Steel, the purpose here is to break up any austenite retained after the quenching operation. It is a well known fact that double or triple tempering in the region of 550/600°C. does improve the cutting quality of certain High Speed Steels. It is possible that the claim made by the firm referred to is based upon this principle.

MR. TAYLOR : There is another process—I think it is the process of Magnetic Treatment after Heat Treatment.

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MR. HARRIES: I am afraid I have no knowledge of this particular treatment.

MR. GILFILLAN: We have had some excellent and some very indifferent results from High Speed Tools which have undergone this electrical treatment. The results depend mainly on the class of work for which the tools are required. To obtain the best results it is advisable for makers to supply the complete analysis of the tools to the firm subjecting the tools to this treatment.

Regarding the secondary or triple tempering of High Speed Steel, there is no doubt that secondary or even triple tempering has very definite advantages in the life of any particular tool. It has been found that where tool life has been exceedingly short when cutting very hard materials, considerable improvement has been obtained by triple tempering.

MR. TAYLOR: With regard to the question of toughness, would not a measure of toughness be controlled by using an unnotched test piece, rather than by a notched test piece?

MR. HARRIES: I have no experience in the use of unnotched test pieces for use in an Impact machine, but I should say that the results would not be anything like as discriminating as those obtained from the usual notched test piece.

MR. MUNRO: The lecturer has, as usual, given a very fine talk which should have the effect of bringing home to production engineers and others, that heat treatment is not a case of pushing work into a furnace, heating it up to a temperature, then cooling it off by some means. His actual lecture does not tell us how much thought is given to the load in a furnace, but his own criticism of some of the slides shown should convey to everyone that there is a right and a wrong way to pack a furnace, or place the instruments to take the necessary temperature readings. None of the slides, however, show us how articles, differing in shape, can be treated by a considered method of packing. One may safely assume that much thought is given to this aspect of heat treatment and, again, in selecting different types of furnace, vertical and horizontal, for specific purposes, bearing in mind at the same time the more practical considerations, such as handling and manner of quenching. Realising that many parts of different sections can be heat treated at one time, he must be certain that all pass the specification requirements on the first submission. It is rather a pity that men with the lecturer's experience are not consulted more often in the design stage, as I do know some of the defects found later could have been avoided. Of course, we cannot blame design only as the Machine Shops are sometimes capable of leaving sharp changes of section radii, etc., which greatly increase the risks in heat treatment.

The lecturer has omitted to draw attention to the risks in oil hardening black forgings and I should, therefore, like him to say a few words on why some forgings or bars are always machined prior to oil hardening and tempering.

Some remarks have been made about residual internal stresses, as well as Izod testing. Is there any connection between these? It is established that material with a low Izod after oil hardening and tempering can be improved by retempering even at a lower temperature, but instead of cooling in the furnace or air, it should be oil or water quenched.

MR. HARRIES: It is quite true, as Mr. Munro has said, that care and attention in the selection of the different furnaces at one's disposal, for specific treatments and types of sections undergoing treatment, constitutes a very important aspect of this subject. For sections which are long in relation to their diameter, particularly where bending and distortion must be kept to a minimum, vertical furnaces are to be preferred. Care and attention in packing a large annealing furnace with a load comprising several forgings liable to 'sag' at high heats is always well repaid.

Most furnaces have their own individual peculiarities but the general tendency is for an upward temperature gradient from the ends towards the middle and, of course, from the floor to the roof, and naturally, this has to be borne in mind when deciding where and how to place the charge, upon the position of thermocouples and the number to be employed.

Changes of section in the part to be heat treated always present a problem, particularly when accompanied by sharply cut radii, etc. When the variation of section within the same component is appreciable, 'mass effect' will exhibit itself in more or less degree, depending upon the chemical analysis of the steel, and will be reflected in the mechanical tests.

As regards the risk associated with oil hardening 'black' forgings, it is obviously the safest practice to rough machine beforehand and where large expensive forgings are concerned I would say that it is rarely worth while to incur this increased risk by oil hardening in the 'black.' Rough machining, of course, removes exterior defects such as seams and superficial cracks which might conceivably extend during heat treatment, and serves generally to prove the surface of the forging. Rough machining naturally reduces the mass of the section undergoing treatment and this is a point which should not be overlooked when considering the possibilities of hardening and tempering in the 'black.' Oil hardening and tempering 'black forgings,' however, can be and is being successfully carried out in many instances where it is economical to do so.

Heat treatment of 'black forgings' is obviously the less 'fool-

proof' method and its application should be decided by the particular merits of the case.

I do not think there is any connection between internal stress and impact value. The explanation for the higher impact values obtained by quenching from the tempering temperature certain steels which show a tendency towards 'temper brittleness' is probably to be sought in the microstructure, although it is not easy to find. The most satisfactory explanation so far, I believe, is that temper quenching allows less facility for carbide, which is held in solution in alpha iron, to separate out and migrate to the grain boundaries.

MR. LEVESLEY : I should like to know why, in the three stage cooling of large forgings, it is necessary to cool in steps in the first cooling but not in the second cooling from 850°C. Can you state what happens during the lower critical range of the second cooling which is shown as a straight curve and also during the final cooling from 650°? Why is it not necessary to introduce steps during all three cooling operations?

MR. HARRIES : The general evidence from much experimental work and practical experience suggests that steel is most susceptible to hair cracks during its first cooling which, incidentally, takes place from a relatively high temperature, typical of, say, casting forging or rolling. The second stage cooling takes place after the steel has been refined at 850°C., and, although this does not mean that the steel is now immune from these defects, experience has indicated that a controlled rate of cooling, without steps, is adequate, at this stage, for the size and type of forgings for which this treatment was prescribed. The final cooling from 650° does not involve any critical changes and is the least important of the three cooling operations, from this point of view.

MR. WALKER : I was wondering whether the same effect would not be reached by prolonging the heat at 620/50° over the same period as for the double anneal. Many people do carry out the tempering at one stage, usually a very long one at about 650°.

MR. HARRIES : I think I must answer that question in the negative although I am conscious that you, Mr. President, may have struck quite a modern note. It is being found, actually, that certain steels can be isothermally transformed from austenite to pearlite by holding at certain fixed temperatures, decided by preliminary experiments, for prolonged periods. This principle is being adopted to works practice in the case of certain steels although not in others in which the transformation temperatures have been found to be most critical and the length of soaking prohibitive.

Taking the structural alloy steels in general, there is, as yet, no satisfactory alternative treatment to the double anneal for the

dual purpose of safeguarding the steel during its first cooling and leaving it reasonably soft and free from stresses and generally in a suitable condition for rough machining and boring.

VISITOR: You mentioned that a nickel chrome steel was prone to 'clink' if care was not taken with the cooling. Would that apply to a manganese molybdenum steel?

MR. HARRIES: Yes, plain carbon as well as alloy steels are liable to 'clink' under certain conditions. Rapid or uneven cooling, particularly of large or irregular sections, leave unsymmetrical residual thermal stresses which tend to promote 'clinking.'

VISITOR: Would you say 'clinks' are more likely to be caused in the heat treatment than in the cooling off after rolling?

MR. HARRIES: No. I do not think so. I should be inclined to look upon either operation with equal suspicion until the particular conditions obtained had been investigated.

A vote of thanks concluded the proceedings.

PRODUCTION ENGINEERING ABSTRACTS

Research Department : Production Engineering Abstracts

(Edited by the Director of Research)

NOTE.—The addresses of the publications referred to in these Abstracts may be obtained on application to the Research Department, Loughborough College, Loughborough.

ANNEALING, CASEHARDENING, TEMPERING.

Practical Application of Flame Hardening, by A. L. Hartley. (*Mechanical Engineering*, July, 1942, Vol. 64, No. 7, p. 531, 22 figs.).

Flame-hardening processes and equipment. Spot hardening. Spin hardening. Progressive hardening. Spiral progressive hardening. Combination spinning and progressive hardening. Flame-hardening equipment. Design features: (1) Spindle speeds ranging from 0.032 r.p.m. to 350 r.p.m. (2) Carriage travel ranging from 3 in. per min., to 20 in. per min. (3) Individual oxygen and acetylene regulators for each burner. (4) Ample tank capacity for coolant. (5) Automatic timing mechanism. (6) Flush quenching. (7) Suitable attachments, including levelling devices, steady rests, chucks, etc. Spot hardening operation on spindle-nose collar spanner-wrench slot. Typical set up for flame hardening a 4-pitch gear. Gears regularly spin-hardened on a production basis. Large crankshaft-lathe cam plate flame-hardened. Large ring gear, an example of a part almost impossible to harden other than by flame hardening. Special burners and their application.

Salt Baths, by R. C. Stewart. (*Machine Shop Magazine*, August, 1942, Vol. 3, No. 8, p. 65, 2 figs.).

Development of salt baths. Salt bath metallurgy. Carburising baths. Alloy case hardening steels. Time-penetration curves for both cyanide and accelerated baths. Malleable iron. Bath operations. Nitriding salts. Chapmanising. Reheating salts. High-speed salts. Tempering salts. Austempering. Hardening Molybdenum high-speed steels. Salt baths for hardening. Procedure for salt bath hardening. Effect of salt bath hardening.

COOLANT LUBRICANTS.

Comparative Tests on the Lubrication of Crankshaft Bearings, by S. F. Dorey and G. H. Forsyth. (*Power Transmission*, August, 1942, Vol. 11, No. 127, p. 305, 6 figs.).

The results of some preliminary tests carried out on three types of bearings to ascertain whether the loading of bearings of the orthodox type can be increased by means of an alteration in the lubricating arrangements.

The tests described are essentially comparative. The formation of an oil wedge. The method of circulating the oil through the bearings. The method of loading the bearing. The general layout of the apparatus. Running-in of bearings.

PRODUCTION ENGINEERING ABSTRACTS

Some Aspects of Industrial Lubrication, by W. J. Hund, R. G. Larsen, Otto Beeck and Harold G. Vesper. (*Mechanical Engineering*, July, 1942, Vol. 64, No. 7, p. 525, 11 figs.).

The mechanism of boundary lubrication. Coefficient of friction in regions of boundary and hydrodynamic lubrication. Four-ball bearing. Wear prevention: role of chemical polishing agents. Wear scar obtained on four-ball tester. Steel pins sliding on rotating steel disk. Use of polar compounds with tricresyl phosphate. Wear of copper-plated balls. Bearing finish. Effect of pressure on viscosity. Types of surfaces. Turbine cils. Bearing corrosion. Thrust-bearing corrosion machine.

EMPLOYEES, WORKMEN, APPRENTICES

Man Power, by Godfrey H. Ince. (*Industrial Welfare and Personnel Management*, July-August, 1942, Vol. XXI V, No. 283, p. 97.).

Registration for Employment order. Essential Work order. Welfare provisions under the essential work order. Personnel management and welfare supervision.

FOUNDRY.

A Mechanised Light-Alloy Foundry. (*Aircraft Production*, September, 1942, Vol. IV, No. 47, p. 548, 28 figs.).

Manufacturing the Rolls-Royce Merlin; the core departments and foundry; gravity diecasting.

Practical Time Study Measurements for Foundry Operations, by P. Carroll. (*Trans. Amer. Foundrymen's Assoc.*, 1941, Vol. 49, p. 503, discussion 523-532, B.N.F. Serial 24,926.).

The method of obtaining "standard data" from which the amount of labour involved in any job can be computed.

(Supplied by the British Non-Ferrous Metals Research Association).

JIGS AND FIXTURES.

Air Clamping as an Aid to Production, (*Machinery*, August 6, 1942, Vol. 61, No. 1556, p. 147, 8 figs.).

A simple air clamping fixture for an oil can casting. An interesting clamping fixture for a milling operation. Arrangement drawing of the clamping fixture for the brush holder assembly. Fixture for clamping six workpieces simultaneously for a milling operation. Air clamping fixture for small disc-type parts.

Expanding Arbors for Lathe Work, by John G. Jergens. (*The Machinist*, August 22, 1942, Vol. 86, No. 19, p. 438, 9 figs.).

Two general types of expanding arbors for lathe work are dealt with. In one type a tapered rod or cam is used to expand pins or keys to hold the work. Such arbors are ideal for holding rough castings or work with irregular inner surfaces. In the other type of arbor, a sleeve or bushing into which several slots have been cut is expanded by forcing a tapered plug into the sleeve. All of these arbors provide a positive locking action.

PRODUCTION ENGINEERING ABSTRACTS

Use of the Rotary Table, by H. A. Frommelt. (*The Machinist*, August 1, 1942, Vol. 86, No. 16, p. 321, 11 figs.).

Cams impart complicated motions to the followers or driven elements. They are used in a wide variety of forms on all kinds of automatic machines. The irregular curves upon which cams depend for their effectiveness, create unusual problems in machining. Radial and barrel cams. A pivoted beam cam. The rather common plate type. Practical cam milling methods. Milling radial or plate cams with a rotary table on a vertical milling machine, or a horizontal miller with a vertical milling attachment, and a rotary table.

MACHINE ELEMENTS.

Heavy Duty Bearings. (*Metal Industry*, Vol. 61, No. 5, July 31, 1942, p. 76).

The performance of copper-lead bearings has been excellent in some operations and very unsatisfactory in others. The use of these bearings will increase because of the shortage of cadmium and tin. To obtain the best results from copper-lead bearings, their field of usefulness from an engineering and mechanical point of view must be known and recognised and they must be applied within the conditions of their field.

It is natural for a copper-lead bearing surface to become coated with a varnish on lacquer deposit ranging in colour from orange to brown, which is beneficial. Even when the deposit changes to a hard, bright, shiny, oily, black surface, it is difficult to connect it with real trouble. A soft, dull black deposit similar to dried-out sludge, often due to the use of high-detergent oils in an old engine, has not been shown to be harmful, either. A hard, dull, black deposit of lead and copper sulphide indicates corrosion of the lead by certain petroleum acids formed in the oil as a result of excessively high operating temperature.

(Communicated by D.S.R., Ministry of Aircraft Production).

Bearings for Diesel Engines, by Albert B. Willi. (*Mechanical Engineering*, June, 1942, Vol. 64, No. 6, p. 439, 27 figs.).

Bearing-lining materials. Relative permissible bearing load plotted against L/D ratio. Chart showing field of usefulness for various bearing metals. Lining thicknesses for different shaft diameters. Recommended oil clearances for various bearing materials. Design elements of connecting rod bearings. Friction and wear. Comparison of four types of bearing metals. Bearing temperature. Bearing life without lubrication. Bearing deterioration. Inlaid bearing. Physical properties of alloys used as bearing linings. Summary of bearing performance in test machine. Summary of bearing performance in engine tests. Bond strengths. Conclusions from review of physical properties. Copper-lead master-rod bearing. Bearing-load capacity reduced by faulty lubrication. Direction of crankshaft drilling influences bearing lubrication. Corrosion and bearing-surface deposits.

CHIPLESS FORMING.

(Sheet) Forming by Drawing, by F. Anderson. (*Aviation*, June, 1942, Vol. 41, No. 6, p. 82.).

The sheet is pulled through forming dies which can be readily adjusted to give any shape. Process can be used for stainless steel, Monel, Mg, brass and Al alloys (including Alclad) and is particularly suitable for the large skin panel requirements of the aircraft industry.

(Supplied by the British Non-Ferrous Metals Research Association).

PRODUCTION ENGINEERING ABSTRACTS

A New Stretching Press. (*Aircraft Production*, September, 1942, Vol. IV No. 47, p. 561, 3 figs.).

A 150-ton American machine by the Hydraulic Press Manufacturing Co., Arrangement of press. Jaw movements.

MANUFACTURING METHODS.

Percussion Fuzes for Small Shell. (*The Machinist*, August 29, 1942, Vol. 86, No. 20, p. 447, 30 figs.).

Arming sleeves, ferrules, shutters, retaining plugs and a number of other parts are turned out in large quantities on single-spindle automatics. Quick check reduces scrap loss. Special taper-turning device. Machining brass striker guides. Operations on brass stemmed plugs. Task jobs on assembly operations.

Marking Methods and Practice, by G. R. Pryor. (*Machinery*, August 20, 1942 Vol. 61, No. 1558, p. 197, 9 figs.).

Metal labels attached by grooved pins or screws. Marking hardened steel tools or parts by etching. The paper transfer method. Acid etching by means of rubber stamps. Marking by machine engraving. The indentation or marking process. Two methods of producing the lettering, designs, or graduations on the marking die. (1) hand cutting, (2) machine engraving. The master copy. Engraving machines. Marking presses. The press method compared with the rolling method.

MATERIALS, MATERIAL TESTING.

New Methods for Mechanical Testing of Plastics. (*L. H. Callender, British Plastics*, Vol. 13, No. 155, April, 1942, p. 445.)

Impact testing to cross-section has been for a long time a need of engineers in many industries, to enable them to test materials in the state in which they are used, instead of relying on doubtful comparative values from specially made-up test pieces. A practical method is here described for impact test to cross-section on electrical plastics.

In the past the difficulty in the way of testing to cross-section has been mainly due to the general use of the excess swing pendulum method with Izod support. The errors of this method, namely the "shearing and tearing" error and the "broken-half" error, are shown by a number of examples to be very large for plastics materials and quite sufficient to invalidate it for comparative brittleness testing of this class of materials.

Comparative brittleness testing to cross-section is shown by numerous results to be bound up with the following:—

(1) The use of the same radius of notch, namely, $\frac{1}{8}$ mm., and the same depth of notch, namely, one-third of the thickness of the test-piece for all tests on pieces of any cross-section.

(2) Charpy anvils adjusted to a distance apart equal to six times the thickness of the particular test-piece under test.

(3) A minimum velocity of impact of 8 ft. (244 cm) per second.

(4) The first definite crack or break must be taken as the end-point of the test.

(5) The use of the guillotine or vertical drop-weight type of machine is also advantageous for this purpose; Photographs of a recommended design of machine are given.

Among other matters touched on is the importance of plastic yield temperature and controlled humidity in relation to impact testing.

PRODUCTION ENGINEERING ABSTRACTS

In the Appendices photographs are given of a new simple machine for plastic yield temperature, and also the interesting theoretical question of the uncertain range is gone into at some length.

(Communicated by D.S.R. Ministry of Aircraft Production).

X-Ray of Aircraft Castings—The Control and Value. (B. C. Bouillon "J. Aeron S.C.I." Vol. 9, No. 8, June, 1942, p. 271).

1. For certain important classes of material X-ray inspection is a valuable tool. Its most important function is the creative one of aiding in the initial development of correct design, dies or patterns, and foundry technique. Its second basic function is that of maintaining a continuing control over foundry practice to ensure maintenance of quality. It is not considered a suitable means for large-scale routine inspection where this is the only purpose served. An important exception to this last statement is the class of vital structural parts with a low ratio of breaking load to design load, which may well be X-ray inspected 100 per cent until further progress is made in foundry control.

2. Defects that can be revealed by X-ray have a marked detrimental effect on the impact and fatigue properties of castings, much greater than the effect on static strength. With skilled and careful interpretation, there is a reasonably good correlation between these properties and the quality of a radiograph.

3. The standards for rejection by radiographic inspection should be based not on the absolute value of the casting quality but on airworthiness considerations and should take cognizance of the ratio between the actual strength of a sound casting and its design load, and also whether the part is subject to unusual conditions of impact or fatigue. A definitely higher X-ray quality should be required for castings with minimum strength factors or those subject to definite impact or fatigue loading. Two or possibly three quality standards should be set up, and the individual having responsibility for rejection must know the quality standard applicable to each casting. Parts subject to impact and fatigue should meet a high quality standard.

(Communicated by D.S.R., Ministry of Aircraft Production).

Application of Geiger-Muller Counters to Inspection with X-Rays and Gamma Rays, by H. Friedman and Others (*Am. Soc. Naval Engineers*, Vol. 54, No. 2, May, 1942, p. 177).

Practically all non-destructive testing with penetrating radiations, utilizes photographic film or fluorescent screens to indicate transmitted intensity. Because such radiation is very weakly absorbed in a photographic emulsion the absolute efficiency of the photographic method of registering intensity is necessarily low. For example, with standard X-ray equipment generating 300 kv. X-radiation, the practical limit for exposure time permits the radiography, at best, of about four inches of steel. With strong sources of radium, it is possible to penetrate greater thicknesses but this is accomplished at the expense of much longer exposures. The radiographing of six inches of steel at eighteen inches source to film distance would require about eight hours with as intense a source as 500 milligrams of radium. There is very slight hope of increasing the speed of the photographic method by any larger factor. Any great gains in efficiency must come through the development of electrical methods and of these, the Geiger-Muller counter applications offer most likelihood of success.

Geiger-Muller counters are a valuable new addition to the older familiar tools of inspection. Their potential applications have thus far been investigated in relatively few laboratories. In this paper questions of sensitivity, speed of measurement and ease of manipulation, have been considered in an

PRODUCTION ENGINEERING ABSTRACTS

effort to show where counters may be used to advantage. A number of applications have been described, some of which are out of the experimental stage and should receive widespread use. Others are still in an early state of development and leave considerable room for further improvement.

(Communicated by D.S.R., Ministry of Aircraft Production).

Two Bronze Alloys for Worm-Gear Application, by B. A. Miller. (*Machinery*, July 9, 1942, Vol. 61, No. 1552, p. 42, (abridged version of paper read before American Gear Manfrs. Assoc.).

Alloys described are a nickel bronze containing 5% Sn, 5% Ni, less than 0.01% Pb, up to 2% Zn; and also P.M.G. alloy. Properties and foundry practice are described.

(Supplied by the British Non-Ferrous Metals Research Association).

Correlation of Residual Stresses in the Fatigue Strength of Axles. (O. J. Horger and H. R. Neifert, "J. App. Mech." Vol. 9, No. 2, June, 1942, p. 85).

The object of this paper is to present a correlation between residual stresses, obtained by heat treatment and measured by the Sachs method (deformation of bored out shell), with fatigue values, determined from an investigation of full-size railway axles. The axles tested were of both solid and tubular design and represent members which could be used under a car in actual service. It was found from these tests that high axle fatigue strength is associated with high surface residual compressive stresses, and lowest axle strength values with surface residual tensile stresses.

(Communicated by D.S.R., Ministry of Aircraft Production).

PLASTIC MATERIAL.

Machining Laminated Plastics, by Herbert Chase. (*The Machinist*, August 22, 1942, Vol. 86, No. 19, p. 434, 8 figs.).

High speeds and light cuts are recommended for this material. Parts can be machined, punched or blanked with standard tools. Typical parts made on a Brown and Sharpe screw machine. Screw machine cams for controlling the tools are made from laminated sheet disks with radial marks at 5 deg. intervals. The cam is cut on a bandsaw. High-speed steel tools are often used, although carbide-tipped tools are best for long runs. Tubes as large as 12 in. dia. are readily turned and bored for radio core forms and other purposes. Die sets similar to those used for metal are employed for punching and shearing laminated strip stock. Synthane products are chemically resistant and are used as containers for pickling of metal parts.

Plastic Flow as an Unstable Process, by L. H. Donnell. (*Journal of Applied Mechanics*, June, 1942, Vol. 9, No. 2, p. A-91, 12 figs.).

Plastic flow frequently proceeds in a discontinuous manner, as in the formation of wedge-shaped plastic regions around the periphery of torsion specimens. This phenomenon can be explained as an instability, brought about by stress concentrations which are caused, not by discontinuities in the shape of the specimen, but by the discontinuous behaviour of the material around the yield point. Yielding first occurs at some region of local weakness. The lagging of the stress in this yielded region causes a stress redistribution around the region, somewhat as if it were a hole which retards stresses and therefore yielding in certain directions while accelerating them in other directions, thus leading to the spontaneous growth of characteristically shaped plastic regions.

PRODUCTION ENGINEERING ABSTRACTS

SMALL TOOLS.

Broach Design, by Fred Schytte. (*The Tool Engineer*, July, 1942, Vol. XI, No. 7, p. 74, 32 figs.).

Given impetus by war work, broaching has become an effective weapon on the industrial battleground. Handicaps. Slab broaching less difficult. Pitch. Chip formation. Material. Chip rating. Chip breakers. Rifling gun barrels. Broaching airplane parts. Broaching ordnance parts. Broaching tank parts. Broaching progress.

Re-Sharpening Broaches. (*Machinery*, August 29, 1942, Vol. 61, No. 1558, p. 210, 4 figs.).

Diagram showing form of a correctly-sharpened broach tooth. Diagram showing form of an incorrectly-sharpened broach tooth. Method used to salvage a broach with a damaged cutting edge. Gauges for checking hook and radius of broach tooth to ensure accurate re-sharpening.

SURFACE, SURFACE-TREATMENT.

Chromium Plating of Brass, by R. B. Eyre. (*Met. Finishing*, April, 1942, Vol. 40, No. 4, p. 192).

An attempt to produce satisfactory Cr coatings without intermediate Ni. Cast and wrought brass specimens were Cr plated with and without the intermediate Ni and tested for durability. The direct Cr coatings on cast specimens were found to be reasonably satisfactory and annealing caused improvements in the wrought specimens. The results lead author to conclude that residual stresses may be the chief cause of bad adhesion.

(Supplied by the British Non-Ferrous Metals Research Association).

Electro-galvanising of sheet and strip from the point of view of mass production, by G. G. J. Adey. (*Sheet Metal Industries*, September, 1942, Vol. 16, No. 185, p. 1309, 7 figs.).

Four main problems presented themselves for solution: (a) elimination of hydrogen, (b) a series of electro-galvanising operations rather than one prolonged immersion, (c) a constant progression through the vat or vats, and (d) the avoidance of bending. Plant for steel sheets. Steel strip plant. Stages of process: (a) Feeding coils into machine, (b) leveller, (c) pickling, (d) washing, (e) rotary cleaning, (f) plating.

WELDING, BRAZING, SOLDERING.

Electric Welding Processes in Relation to Automobile Construction, by W. S. Simmie. (*Welding*, August, 1942, Vol. X, No. 7, p. 143, 6 figs.).

Selection of material. Installation of welding equipment. Spot welding. Welding current. Welding time. Electrode pressure. Welding dies. Design for welding. Component parts used in the construction of a spot welded chassis. Spot welding of chassis frames. Overcoming inductive losses in secondary welding circuit. Visual inspection. Types of welding dies used to avoid disturbance of the metal surface. Flash welding of automobile bodies. Arc welding. Automatic arc welding. Semi-automatic arc welding of body panels.

PRODUCTION ENGINEERING ABSTRACTS

"Sewing" Alclad Aluminium, by W. E. Klingeman. (*Iron Age*, May 7, 1942, Vol. 149, No. 19, p. 69).

Equipment and procedure for roll spot welding by the condenser discharge method, by which 300 precision spaced spot welds per minute can be made.

(Supplied by the British Non-Ferrous Metals Research Association).

The Production of Small Assemblies by Means of Brazing Processes, by H. R. Brooker. (*Sheet Met. Ind.*, May, June, 1942, Vol. 16, Nos. 181, 182, pp. 669 and 843).

A full analysis of brazing processes, equipment, materials and techniques written in conjunction with the Advisory Service on Welding, Ministry of Supply, by whom it is being issued as a technical memorandum.

(Supplied by the British Non-ferrous Metals Research Association)

WELFARE, SAFETY, ACCIDENTS.

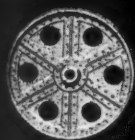
Reducing Maintenance Work, by C. J. Parker. (*Machine Shop Magazine* August, 1942, Vol. 3, No. 8, p. 42, 6 figs.).

The normal method of attaching a guard. The use of extensions for over-running tables. A planer fitted with concertina guards. A pair of guards for use on a large slideway grinder. A typical guard for slideways. Clips on the gusset reduce rubbing of the guard on the slide.

WOODWORKING.

Moulded Plywood Aircraft. (*Aircraft Production*, September, 1942, Vol. IV, No. 47, p. 544, 5 figs.).

Plywood in its modern form, bonded with synthetic resin adhesives, has made a notable return to the aircraft world as a constructional material. Plywood moulding. Building up the plywood skin of a half-fuselage on a wooden mould, and stapling in position. Applying the skin. Rubber counter mould. A completed port half-fuselage after withdrawal from the pressure chamber, being removed from the mould. Skin and supporting structure are bonded into an integral unit.

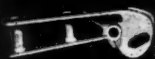
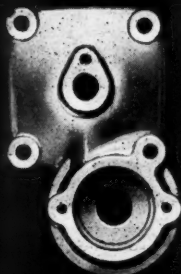
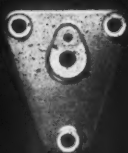


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Printed by Richard Bates, Limited, 9-13, Stockton Street, All Saints, Manchester 15.

